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Environmental Implications of Trends in Agriculture and Silviculture

Volume II
Environmental Effects of Trends

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This study assesses those trends in U.S. agriculture and silviculture that will have the most significant environmental implications, either beneficial or adverse, in the short term (1985) and in the long term (2010). Volume I identifies trends in irrigated and nonirrigated crop production, feedlot production, range and pasture management, and silviculture and harvest management. Volume II identifies the major ecological impacts of the major trends on aquatic life, terrestrial life, and human health. The second volume also contains an assessment of continuing research needs and prospective policy issues involving environmental quality management.

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ENVIRONMENTAL IMPLICATIONS OF TRENDS IN AGRICULTURE AND SILVICULTURE

Volume II: Environmental Effects of Trends

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FOREWORD

Environmental protection efforts are increasingly directed towards preventing adverse health and ecological effects associated with specific compounds of natural or human origin. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, management or engineering tools are developed for assessing and controlling adverse environmental effects of non-irrigated agriculture and of silviculture.

Agricultural and silvicultural practices, already significant sources of water and air pollution, represent areas of increasing environmental concern as these production systems expand to meet growing population needs. This study assesses the environmental implications and effects of short- and long-term trends in American agriculture and silviculture and identifies research needs and policy issues. The developed information should benefit environmental managers as they attempt to anticipate pollution problems of the future.

David W. Duttweiler
Director
Environmental Research Laboratory
Athens, Georgia

PREFACE

The results of this research study, the "Environmental Implications of Trends in Agriculture and Silviculture," are presented in two parts: Volume I: "Trend Identification and Evaluation," and Volume II: "Environmental Effects of Trends."

Volume I identifies, defines, rates, and rank-orders the most important environmentally related trends within all major subsectors of agriculture and silviculture. The environmental ratings and rankings were made by selected panels of professionals from throughout the nation on the basis of the Contractor's interim report of trend-by-trend assessments. Over 240 specific subtrends, representing over 70 trend groupings, were evaluated across five panel areas -- subsectors of agriculture and silviculture. These panel areas were: (1) nonirrigated crop production, (2) irrigated crop production, (3) feedlot production, (4) range and pasture management, and (5) silviculture and harvest management. Separate sections of the Volume I report are devoted to each of these panel areas of study.

Volume II extends the environmental assessment for major trends from each panel area, primarily from the crop production subsectors. Ultimately, the main evaluations of Volume II were assessments of each trend's probable ecological effects, i.e., aquatic life, terrestrial life and human health impacts. These evaluations were also completed by professionals in a workshop setting on the basis of the Contractor's background summary of detailed findings for each trend-subtrend. Volume II also contains an assessment of continuing research needs and prospective policy issues involving agriculture and silviculture and environmental quality management.

Throughout the study both short-term (1985) and long-term (2010) effects were evaluated, although emphasis was placed on the long-term. Furthermore, the study considered the beneficial as well as the adverse effects of trends in agriculture and silviculture to recognize that the nation's environmental quality can perhaps be as readily enhanced through the promotion of beneficial trends as through the control of adverse trends. Finally, the research approach of this study relied heavily upon the value judgements of professionals from agriculture and silviculture. We believe that the composite, informed professional judgements presented here are most reflective of the environmental implications of trends in agriculture and silviculture.

ABSTRACT

This study assessed those trends in U. S. agriculture and silviculture which will have the most significant environmental implications, either beneficial or adverse, in the short-term (1985) and in the long-term (2010).

The study's findings are reported in two parts. Volume I identified relevant trends and rated their environmental implications for five major subsectors of agriculture and silviculture: (1) nonirrigated crop production, (2) irrigated crop production, (3) feedlot production, (4) range and pasture management, and (5) silviculture and harvest management. Volume II extended the environmental effects analysis of selected major trends from each subsector, primarily the identification of major ecological impacts of the major trends on aquatic life, terrestrial life and human health. A second study workshop was conducted to ascertain probable ecological effects where data constraints currently exist.

Volume II also contains the study's identification of research needs germane to a more definitive assessment of the environmental and ecological effects of the five subsectors, and the study's development of prospective policy issues which are likely to emerge from the five subsectors.

The research needs range widely, but were classified into four primary research categories: production efficiency, pollution measurement, pollution reduction, and ecological impact. A fifth category, extensiveness research, completes the framework of research needs, but this category is largely outside EPA's primary areas of responsibility. The prospective pollution control policy issues discussed all emanate from three basic policy areas: control of wastes from production processes, control of polluting inputs, and control of management practices to reduce pollutants generated. Each subsector of agriculture and silviculture has both research needs and prospective policy issues within these four research categories and within the three basic pollution control policy areas, as reported.

This report was submitted in fulfillment of EPA Contract No. 68-03-2451 by Development Planning and Research Associates, Inc., Manhattan, Kansas, and its subcontractor, The Tuolumne Corporation, Corte Madera, California, under the sponsorship of the Environmental Protection Agency. Work was completed as of December 1977.

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Particularly important to this study, also, were the individual and combined efforts of the evaluation workshop participants (both in the Volume I and Volume II portions of study) who assessed the environmentally-related trends in agriculture and silviculture, 1976-2010. These participants, as briefly named below by panel area, are identified further within the report. DPRA sincerely acknoledges their contributions.

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Samuel G. Unger
Principal Investigator

EXECUTIVE SUMMARY

This "Environmental Implications of Trends in Agriculture and Silviculture" study for the Environmental Protection Agency determined and assessed those trends in U.S. agriculture and silviculture which will have the most significant beneficial or adverse environmental implications in the short-term (1985) and the long-term (2010). Volume I identified those trends and evaluated their environmentally germane developments in all major subsectors of agriculture and silviculture. Volume II presents a detailed assessment of the environmental effects of selected major trends and of their related research needs and prospective policy issues involving pollution controls in agriculture and silviculture.

Two phases of research (Volumes I and II) were involved in the study. The present volume, Phase II, extends the trend identification research of Volume I by further examining those trends which were evaluated as having relatively greater environmental implications. In particular, for those selected trends as shown in Exhibit 1, more detailed trend-subtrend assessments were completed to determine: (1) their current and expected extensiveness of use, (2) their associated productivity changes, (3) their effects on resource-use patterns, and (4) their expected pollutant changes by media (water, air, and land) in relation to conventional practices. On the basis of these analyses, each subtrend's ecological effects were also estimated.

For the agriculture sector's trend assessment, an ecology workshop was conducted to determine the expected ecological effects of the selected trends and subtrends. A panel of professional ecologists and agriculturalists utilized the Contractor's preliminary report of findings (Appendix A) to rate, on an index scale, both the adverse and the beneficial ecological effects associated with each subtrend. For the silviculture sector's trend assessment, a comprehensive literature search was completed, including an analysis of each subtrend's known or anticipated ecological effects (Appendix B). In general, relatively more environmental and ecological effects research has been completed for silviculture, and hence, a workshop evaluation approach was not considered necessary for this sector.

For both agriculture and silviculture, three principal categories of ecological effects were assessed for each subtrend: aquatic life, terrestrial life and human health effects. For the silviculture sector, two additional categories were assessed--aesthetics and recreation opportunity. These latter environmentally-related effects categories are especially important in silviculture and are often a principal concern of forest management practices.

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Exhibit 1. Trends and subtrends in agriculture and silviculture selected for Phase II assessment

Sector/Trends	Subtrend
	A. AGRICULTURE SECTOR
Crop Production	
1. Runoff and Erosion Control	1.1 Contour farming/contour strip cropping
	1.2 Terraces and grass waterways
	1.3 Optimizing time of operations
	1.4 Narrow rows
	1.5 Winter cover crop
2. Conservation Tillage	2.1 No-tillage
	2.2 Reduced tillage
3. Improved Water Application	3.1 Furrow basins
	3.2 Land grading
	3.3 Sprinklers
	3.4 Recycling and controlling tailwater
	3.5 Irrigation scheduling and efficiency
4. Improvement Seed and Plants	4.1 Weather resistance
	4.2 Salt resistance
	4.3 Production efficiency
	4.4 Disease and insect resistant
5. Scouting and Integrated Controls	5.1 Surface scouting
	5.2 Remote sensing scouting
	5.3 Integrated controls
6. Development of New Biological and Chemical Pesticides	6.1 Micro-encapsulated
	6.2 Systemic pesticides
	6.3 Surfactants for herbicides
	6.4 Bio-degradable pesticides
	6.5 Alternative formulations
	6.6 Juvenile hormones
	6.7 Pheromones
	6.8 Sterile males
	6.9 Predators and parasites
7. Methods of Nutrient Application	7.1 Foliar application
	7.2 Multiple application
	7.3 Fall application
	7.4 Liquid fertilizer
	7.5 Aerial and floater application
	7.6 Improved nutrient placement
	7.7 Irrigation application
8. Soil-Plant Analysis	8.1 Soil-Plant analysis
Feedlot Production	
9. Alternative Residual Disposal	9.1 Off-site disposal--solids and liquids
Range and Pasture Management	
10. Grazing Practices and Stocking Rates	10.1 Continuous grazing
	10.2 Specialized grazing
	10.3 Complementary forage seedings
	10.4 Controlled livestock grazing
	B. SILVICULTURE SECTOR
1. Access to Timber Resource	1.1 Permanent road construction
	1.2 Road maintenance
	1.3 Project road construction
	1.4 Road reconstruction
2. Site Preparation	2.1 Log extraction
	2.2 Mechanical preparation
	2.3 Burning prescription
	2.4 Chemical treatment
	2.5 Fertilizer treatment
	2.6 Soil moisture control
3. Log Extraction	3.1 Harvest unit layout
	3.2 Equipment use and development
4. Utilization	4.1 Extraction residue recovery
	4.2 Minimum size and quality extension
	4.3 Species use enlargement
5. Cutting System	5.1 Clearcutting

Following the ecological effects assessments for agriculture and silviculture, a comprehensive review was made of both Phase I and Phase II developments to identify the continuing research needs and policy issues (particularly for nonpoint sources of pollution) of agriculture and silviculture related to the anticipated problems of controlling these sources of pollution.

Results of the Study

Three main types of results were obtained in this study: (1) the identification of the environmental and ecological effects of leading trends in agriculture and silviculture, (2) the identification of their related research needs, and (3) the identification of their related policy issues. Each of these are summarized as follows:

1. Environmental and Ecological Effects

A principal result of this Phase II research was the environmental analysis of selected trends and subtrends from both agriculture and silviculture, including an assessment of each subtrend's ecological effects.

Exhibit 2 summarizes the ecological effects ratings of the ecology workshop for the subtrends assessed in the agriculture sector. These ratings, either beneficial (+) or adverse (-) on a scale of 1 (minor) to 5 (major) relative to 1976 conditions were made for the short-term (1985) and long-term (2010). Separate ratings, as shown, were made for aquatic life, terrestrial life and human health effects. The workshop concluded that aquatic life and terrestrial life effects of agriculture's trends and subtrends are not expected to change significantly on the national level by 1985; however, moderate to important changes can be expected by 2010 under the study's baseline agricultural growth assumptions (Volume I). For the most part, the changes are expected to be beneficial, rather than adverse, as illustrated in Exhibit 2. For example, trends in runoff and erosion control and in conservation tillage methods in the cropland production subsector will generally have beneficial aspects. Their net effect is not clear, however, when both beneficial and adverse changes are predicted. Human health effects are generally expected to be minor with little anticipated differences from current conditions for most of the agriculture trends and subtrends assessed.

For the silviculture sector, similar assessments were made based on literature search findings as discussed in detail in Section II. In addition, the aesthetic and recreation opportunity effects of silviculture's trends and developments are evaluated, since in many cases, these effects are of primary concern. Because of silviculture's long growth-harvest cycles, many of the aquatic, terrestrial, and human health effects are, relative to those of agriculture, rather short-lived. Most practices which alter forest sites, e.g., access, harvest or site preparation, will, however, have potential adverse effects, including more extended aesthetic and recreation opportunity impacts.

Exhibit 2. Summary of ecological effects ratings of trends and subtrends in the agriculture sector

Trend		Subtrend	Ecological Effects Rating					
			Aquatic		Terrestrial		Human Health	
			1985	2010	1985	2010	1985	2010
			--------Index Rating [1]--------					
Crop Production								
1. Runoff and Erosion Control	1.1	Contour farming/contour strip cropping	+1	+4	+1	+3	0	0
	1.2	Terraces and grass waterways	+1	+3	+1	+3	0	0
	1.3	Optimizing time of operations	+1	+1	+1	+2	0	0
	1.4	Narrow rows	0	+1	0	+1	0	0
	1.5	Winter cover crop	0	+1	0	+1	0	-1
2. Conservation Tillage	2.1	No-tillage	+2;-1[2]	+3;-1	0	0	0	0
	2.2	Reduced tillage	+2;-1	+3;-1	0	0	0	0
3. Improved Water Application	3.1	Furrow basins	-2	-3	-2	-3	-1	-1
	3.2	Land grading	-1	-1	-1	-1	0	-1
	3.3	Sprinklers	-1	-2	-1	-1	0	0
	3.4	Recycling and controlling tailwater	+2	+3	-1	-1	+1	+1
	3.5	Irrigation scheduling and efficiency	+1	+1	0	+1	0	0
4. Improvement Seed and Plants	4.1	Weather resistance	0	0	0	0	0	0
	4.2	Salt resistance	0	-1	-1	-1	0	0
	4.3	Production efficiency	0	-1	0	0	0	0
	4.4	Disease and insect resistant	+2	+4	+1	+3	+1	+2
5. Scouting and Integrated Controls	5.1	Surface scouting	+1	+3	+1	+3	0	+1
	5.2	Remote sensing scouting						
	5.3	Integrated controls	+1	+4	+1	+4	0	+2
6. Development of New Biological and Chemical Pesticides	6.1	Micro-encapsulated	+1	+3	+1	+2	+1	+2
	6.2	Systemic pesticides						
	6.3	Surfactants for herbicides						
	6.4	Bio-degradable pesticides						
	6.5	Alternative formulations						
	6.6	Juvenile hormones	+1	+3	+1	+3	+1	+3
	6.7	Pheromones						
	6.8	Sterile males						
	6.9	Predators and parasites						
7. Methods of Nutrient Application	7.1	Foliar application	0	0	0	0	0	0
	7.2	Multiple application	+1	+1	0	+1	0	0
	7.3	Fall application	-2	-3	0	0	-1	-1
	7.4	Liquid fertilizer	0	0	0	0	0	0
	7.5	Aerial and floater application	0	0	+1	+2	0	0
	7.6	Improved nutrient placement	0	0	0	0	0	0
	7.7	Irrigation application	-1	-1	0	0	0	0
8. Soil Plant Analysis	8.1	Soil plant analysis	±1	±2	0	0	0	0
Feedlot Production								
9. Alternative Residual Disposal	9.1	Off-site disposal- solids and liquids	-1	-2	+1	+1	-1	-1
Range and Pasture Management								
10. Grazing Practices and Stocking Rates	10.1	Continuous grazing	+1	+2	+2	+3	0	0
	10.2	Specialized grazing						
	10.3	Complementary forage seedings	0	0	0	-1	0	0
	10.4	Controlled livestock grazing	+1	+1	+1	+3	0	0

---

[1] Index rating = beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor, 2 = limited, 3 = moderate, 4 = important, and 5 = major.

[2] Aquatic effects of no-till and reduced tillage were divided into two areas. The beneficial (+) rating reflects the aquatic effect resulting from decreased sediment in surface waters. The adverse (-) rating reflects the result of increased pesticide use with those practices.

2. Research Needs

A continuing need exists to improve the information and data base for conducting meaningful environmental effects assessments in agriculture and silviculture. In this study, four categories of research needs were enumerated and discussed:

1. Production efficiency research
2. Pollution measurement research
3. Pollution reduction research
4. Ecological impact research

A fifth research category, extensiveness research, is also implicitly required; however, this research is generally beyond EPA's primary responsibility.

Production efficiency research is necessary to assess the direct and indirect pollution effects of those technologies used to improve production yield and efficiency. Pollution measurement research is needed to determine the actual types and quantities of pollution generated by alternative agricultural and silvicultural production processes under various environmental conditions. Pollution reduction research is needed to assess the effects of alternative methods to reduce the generation of pollutants. And, ecological impact research is needed to quantify the various types of environmental and ecological effects associated with both individual and composite production activities.

A detailed summary of this study's identified research needs for the agriculture sector is presented in Exhibit III-1 of the text. Specific research needs are arranged by agriculture subsector and by the above four research categories. A similar summary for the silviculture sector is shown in Exhibit III-2.

Insofar as the control of pollution is a principal goal of EPA, two of the above research categories, i.e., production efficiency research and pollution reduction research, are of primary importance. Production efficiency research, for instance, is an indirect form of pollution control, for improvements in production efficiency will inhibit the expanded use of potentially polluting resources to meet specified output levels. Pollution reduction research examines those activities and resources which, when applied, will directly affect pollution levels.

Of important note is the finding of this Phase II study that it is presently impossible to specify an established and detailed, heirarchical delineation of research needs. The study's workshop recognized that it is not readily apparent which research activities would have the greatest expected environmental effects. Present knowledge, for instance, is insufficient to determine whether it is better to expand research to develop improved seeds and plants to enhance production efficiency or whether to develop improved no-till methods for run-off and erosion control in order to most effectively control pollution levels in the future.

The following examples of research needs as defined for the various subsectors of agriculture and silviculture in the production efficiency and the pollution reduction research categories are illustrative of both the findings and the complexity of the environmental implications of trends in agriculture and silviculture:

Sector/Subsector	Type of Research Need Production Efficiency	 Pollution Reduction
Agriculture Sector		
. Crop Production	Develop more efficient farm implements for soil and water management. Develop more resistant seeds and plants, including resistance to weather, insects, salt and nematodes. Develop sources, both legume and non-legume, of biological nitrogen fixation. Develop more effective integrated pest control systems including improved, more effective chemical and biological pesticides.	Develop and determine effectiveness of alternative reduced tillage methods for lowering pollutant losses, e.g., nutrients, pesticides, sediment. Develop and determine the feasibility of water renovation through filtering and desalting. Develop fertilizers designed to reduce pollution effects, e.g., microencapsulation.
. Feedlot Production	Assess the efficiency and feasibility of recycling wastes in feeding rations	Evaluate ration rotation as a means of reducing the potential build-up of copper, arsenic, and sodium derived from feed rations.
. Range and Pasture	Develop more effective grazing systems utilizing innovations such as complementary forage seedings.	
Silviculture Sector		
. Harvest Management	Determine optimum level of utilization of biomass in commercial forests and means of projecting environmental effects under varying cutting levels.	Determine kinds, volumes, and sizes of material that should be left on site to aid in controlling pollution resulting from varying levels of utilization.
. Stand Control	Determine minimum amount of site preparation to meet requirements for regeneration.	Develop equipment to minimize pollution effects of site preparation.

Besides these examples of production efficiency and pollution reduction research needs which can either directly or indirectly affect pollution levels in the future, numerous research requirements, as summarized in Exhibits III-1 and III-2 of the report, involving pollution measurement and ecological impacts are also needed. Such monitoring activities are essential within the context of research both to better understand the impacts of pollution in the environment and to assess the progress of developments in agriculture and silviculture.

3. Policy Issues

The third major result of this study was its identification of prospective environmental policy issues which emerge as a consequence of the environmental implications of trends in agriculture and silviculture. Such issues are germane because of EPA's legislative requirements (such as under the Federal Water Pollution Control Act, PL 92-500) to establish effective pollution controls for both point and non-point sources.

Agriculture and silviculture pollution control can be attained in only three basic ways:

(a) the control or treatment of wastes generated by production systems;
(b) the control of use of polluting inputs; and
(c) the control of management practices to reduce pollutants generated.

Policy issues arise as a direct consequence of the consideration of public measures to influence any or all of these control approaches.

A general summary of the policy issues identified in this study, categorized by the three types of control as indicated, is presented in Exhibit IV-1 in the report. For both the agriculture and silviculture sectors, policy issues involving the control or treatment of wastes, *per se*, may generally lack feasible implementation alternatives because of the dispersed and fugitive nature of non-point sources of pollution. Consequently, relatively more policy issues were identified in relation either to the control of inputs or to the control of management practices. The following examples of policy issues germane to input and management practice controls are illustrative of the findings of this study by subsector of agriculture and silviculture.

	Basic Policy Area	
Sector/Subsector	Control of Inputs	Control of Management Practices
Agriculture		
. Crop Production	Affect the amounts and types of resources used, including land, nutrients, pesticides, water, etc.	Affect run-off and erosion controls, conservation tillage practices, water application practices, wind erosion controls, crop sequencing practices, and others.
. Feedlot Production	Affect land-use off-site disposal requirements, and feedlot size.	Develop and affect use of alternative residual disposal methods. Control practices via feedlot size.
. Range and Pasture Management	Affect use of land, nutrients and pesticides.	Affect grazing practices and stocking rates.
Silviculture		
. Harvest Management, Stand Control and Damage Control	Affect use of land, nutrients and pesticides.	Affect access developments, site preparation practices and fire control practices.

The policy issues identified here are stated without specific consideration of the type of implementation method which may be feasible or most practicable. In actuality, alternative implementation methods may be applicable, e.g., regulations, economic incentives, education, or public investments. Further, various indirect policy issues, such as foreign agricultural trade issues, were not assessed in this study, yet such issues will exogenously affect environmental quality management needs in the agriculture and silviculture production sectors of the U.S. economy.

SECTION I

INTRODUCTION

As was documented in Volume I of this two-volume report, the agriculture and silviculture sectors of the U. S. economy are major contributors of environmental pollution. However, because these pollutants are generally widely dispersed, their environmental effects are often uncertain; and, based upon available data, neither the scope nor the full effects of agricultural and silvicultural pollutants are accurately known.

The goal of this research was not to isolate agriculture's and silviculture's absolute contribution to overall environmental pollution; rather, at best, this study sought to determine the relative environmental effects that trends and developments would likely have in the future vis-a-vis the current environmental quality.

That is, the study basically asked: "What changes in environmental effects are likely if trends and developments in agriculture and silviculture continue into the short-term (1985) and the long-term (2010)?" Within this context, what specific trends (or component subtrends) may eventually produce either beneficial or adverse environmental effects in comparison to current, conventional practices.

In Volume I of this study, the emphasis was toward trend identification and a relative ranking of environmentally-related agricultural and silvicultural trends according to their expected environmental implications--either beneficial or adverse. Volume II extends the environmental assessment of the most highly rated trends as determined in Volume I.

The Volume II assessment ultimately focused on the potential ecological effects of specific practices and probable developments, or subtrends, within selected trends. The primary ecological effects evaluated were aquatic life, terrestrial life and human health impacts. Additionally, however, the assessment included a detailed analysis of each subtrend's extensiveness of use, productivity changes, resource use patterns, and pollutant changes by media. This latter analysis provided the basis for an ecology panel workshop for the agricultural sector in which the ecological effects of each selected subtrend-trend were investigated.

A. Scope of Study

This study for the Environmental Protection Agency sought to determine and assess those current and emerging trends in U. S. agriculture and silviculture which will have the most significant environmental implications--either beneficial or adverse. The two main objectives of the analysis were:

(1) to assess the environmental implications and impacts of both short-term (1985) and long-term (2010) trends in American agriculture and silviculture, and

(2) to identify pertinent environmental issues, associated research needs and policy issues.

To accomplish these objectives, two phases of work were involved in the overall study:

> Phase I, the subject of the Volume I report, determined on a priority basis the major environmentally-related trends in agriculture and silviculture, and
>
> Phase II, the subject of this Volume II report, assessed the environmental effects (particularly the ecological impacts) of selected major trends, and identified associated research needs and policy issues.

In the conduct of this research, evaluation workshops comprised of agricultural, silvicultural, and other basic science professionals were utilized to rate, assess and modify, as needed the Contractor's Phase I and Phase II preliminary findings. The Phase II workshop panel and procedures are described more fully below.

B. Phase II Procedures

In preparation for the agriculture sector ecological effects workshop of Phase II, the Contractor prepared an interim background summary for the participants. This report documented for each subtrend its current and projected extensiveness of use, productivity effects, resource use changes and pollutant changes by media, and this documentation served as the information basis for the workshop assessment. (This background summary, plus workshop evaluation forms, are included in Appendix A.)

In Phase II, a single panel of experts was selected to assess the ecological effects of subtrends and trends in agriculture--covering all subsectors, i.e., crop production (both nonirrigated and irrigated), feedlot production, and range and pasture management. Subtrends and trends in silviculture were separately assessed because of the significant differences of this sector's growth-production-harvest cycles and of generally intermittent environmental-ecological effects of its activity in any given location. This assessment of silvicultural trends was based principally on research literature. A background summary of research findings and conclusions for the silviculture sector is included in Appendix B.

The ecology workshop participants for the agriculture sector met in general sessions to assess and rate the potential change in ecological effects of each subtrend within the selected trends. In particular, three types of ecosystem effects were evaluated: aquatic life, terrestrial life and human health. A fourth type of effect, wildlife habitat, originally projected by the Contractor, was determined by the workshop to be properly considered within either the aquatic life or terrestrial life categories. Hence, only three types of effect were included in the final analysis; however, wildlife effects were frequently described within either the aquatic or terrestrial categories.

With the Contractor's background summary as a guide, the workshop first assessed the summary provided and modified the summary conclusions where necessary. This discussion led to a common basis of understanding for the subsequent ecological effects ratings for 1985 and 2010 relative to 1976 (or current conditions). Also, it was agreed that the assessment would accept the Phase I (Volume I) workshop panels' judgements as to the probable extensiveness of use of each of the subtrends in relative terms, i.e., the index ratings of the direction and magnitude of each subtrend as determined in Phase I. The Contractor supplemented these ratings with quantified data whenever possible.

The workshop was asked to rate the direction and magnitude of change in ecological effects which could be expected by 1985 and by 2010 from the current period, 1976, as follows:

Type of Effect	Direction	Relative Magnitude
Aquatic life [1]	(+) = beneficial	1 = minor
Terrestrial life [1]	(-) = adverse	2 = limited
Human health		3 = moderate
		4 = important
		5 = major

[1] Includes wildlife habitat

As was explained to the workshop, the rating scale from 1 to 5, or minor to major, was purely judgemental not only within the panel, but to other investigators. Nevertheless, the ratings and their dispersion across subtrends-trends were deemed as important indicators of environmental effects. Furthermore, it was the objective of this workshop that "consensus" ratings be obtained from the panelists--rather than completely independent ratings. The rationale for this approach was that it would better integrate the ideas and knowledge of these professionals and that while differences would exist, such differences would be best resolved through qualifying remarks and their rationale for any given rating. (Note: Further assessments of distributions in initial rating responses are desirable, but they were not considered statistically useful in this study since relatively few panelists were involved and pre-workshop ratings were not specifically requested.)

C. The Ecology Workshop

The participants of the Phase II ecology workshop for the agriculture sector represented a cross-section of professional scientists whose primary activities are directly involved with environmental and ecological effects of man's activities. These participants and their principal areas of expertise are as follows:

Participant	Area of Expertise
Dr. Lloyd C. Hulbert Manhattan, Kansas	Aquatic and terrestrial effects
Dr. S. Mac King Wheaton, Illinois	Agronomy, soils and environmental effects of agricultural practices
Dr. H. P. Nicholson Athens, Georgia	Human health and environmental effects of pesticides in soil and water
Dr. Fred W. Oehme Manhattan, Kansas	Toxicology and human health effects
Dr. Walt H. Wischmeier Lafayette, Indiana	Runoff and soil erosion in relation to alternative agricultural practices
Dr. John L. Zimmerman Manhattan, Kansas	Aquatic and terrestrial effects, including wildlife

SECTION II

ENVIRONMENTAL AND ECOLOGICAL EFFECTS ASSESSMENT

Only selected trends in agriculture and silviculture, based on the Phase I evaluation, were included in this Phase II environmental and ecological effects assessment. Each of the trends and associated subtrends included were previously assessed as major environmentally-related trends by the Phase I evaluation workshop. These trends are as outlined in Exhibit II-1, below, and include ten trends from the agriculture sectors and five from silviculture, as shown.

In order to conduct the more detailed environmental and ecological effect assessment of Phase II, additional literature reviews were completed and research findings were summarized. For the agriculture trends selected, an interim background summary report was prepared and distributed to the ecology workshop participants as a basis for their workshop evaluations. This background summary material is included in Appendix A, and it primarily contains data on the extensiveness of use of each subtrend, productivity effects, resource use changes, and pollutant changes by media for each subtrend compared to other related conventional practices. Specific references to the research findings as reported are also cited. For the silviculture trends, a similar review of literature was completed as summarized in Appendix B; however, a workshop assessment was not conducted.

The principal focus of the agriculture sector workshop assessment was on each trend-subtrends' potential ecosystem impacts relative to current (1976) conditions. In particular, three types of ecological effects were evaluated and rated: aquatic life, terrestrial life and human health. Judgemental rating values were determined for each type of ecological effect corresponding to either beneficial (+) or adverse (-) changes in effect on a scale of 1 to 5, where 1 = minor and 5 = major, as explained in detail in Section I, above. The workshop participants accepted the challenge of such a relative rating approach, realizing the variability that obviously exists in not only the presence of known pollutants but especially in the loadings or dosage levels of pollutants as they interface with receptor organisms.

Ideally, ecological assessments would be conducted under much more rigorous conditions with detailed quantitative statistics regarding pollutants, receptor characteristics such as assimilative capacities, organisms present, end-uses, and others. Such data are generally meager, however, and professional judgements are mandatory if even relative indicators of environmental effects of agriculture's and silviculture's production activities are to be obtained.

Exhibit II-1. Summary of top ranked (vis-a-vis their environmental implications) Phase I trends in agriculture and silviculture including identification of Phase II trends

Agriculture Trends	Phase I Workshop Rank	Phase II Trend Numbers: Agriculture
Runoff & Erosion Control (Nonirrigated) 1/	1 2/	1
Conservation Tillage (Nonirrigated)	2	2
Improved Water Application (Irrigated)	3	3
Runoff & Erosion Control (Irrigated)	4	1
Improvement of Seeds & Plants (Nonirrigated)	5	4
Scouting & Integrated Controls (Nonirrigated)	6	5
Developing New Biological & Chemical Pesticides (Nonirrigated)	7	
Feedlot Design for Waste Management (Feedlot) 3/	8	--
Feedlot Size (Feedlot) 3/	9	--
Alternative Residual Disposal (Feedlot)	10	9
Method of Nutrient Application (Irrigated)	11	7
Grazing Practices (Range & Pasture)	12	10
Stocking Rates (Range & Pasture)	13	10
Developing Integrated Controls (Irrigated)	14	5
Renovation (Range & Pasture)	15	--
Soil Plant Analysis (Irrigated)	16	8
Odor Control (Feedlot)	17	--
Using Increased Resources (Range & Pasture)	18	--
Feed Efficiency and Rations (Feedlot)	19	--
Range & Pasture Improvement (Range & Pasture)	20	--

Silviculture Trends	Phase I Rank by 4/ Silviculture Panel	Phase II Trend Numbers: Silviculture
Access to Timber Resource	1	1
Site Preparation	2	2
Log Extraction	3	3
Utilization; Logs & Residues	4	4
Cutting System	9	5

1/ In Phase I, agriculture trends represented four subsectors: (1) Irrigated Crop Production; (2) Nonirrigated Crop Production; (3) Feedlot Production; and, (4) Range & Pasture Management.

2/ Brackets indicate combined agriculture trends for Phase II assessment.

3/ In Feedlot Production, the first two ranked trends were excluded from Phase II because EPA point source analysis and controls will apply.

4/ Silviculture trends were ranked separately in Phase I by the Silviculture panel and were not included in overall workshop rankings.

The environmental and ecological effects assessments for agriculture and silviculture, which follow, represent both research findings from the literature and expert judgements. The ecological effects of trends in agriculture were primarily evaluated in a workshop setting as previously described. The panel itself placed most credence on the direction of ecological effects as defined below, and tried to reflect differential relative changes among subtrends via the rating scale adopted. However, it is impossible to precisely indicate in an index fashion all potential effects under all possible conditions. Each subtrend itself might present major ecological problems on a local-regional level.

A. Agriculture Sector Trends

The agriculture sector trends are divided into three subsectors in Phase II: crop production (irrigated and nonirrigated), feedlot production, and, range and pasture management. (In Phase I, the irrigated and nonirrigated crop production subsectors were assessed separately.) Ten (10) trends and 41 subtrends from these three subsectors, as shown in Exhibit II-2, are assessed. In particular, the trends numbered 1 thru 8 are selected trends from the crop production subsector; trend 9 is from the feedlot production subsector; trend 10 is from the range and pasture management subsector.

The rationale for the selection of these trends was that basically each trend was rated as having relatively high environmental implications by the Phase I evaluation workshop -- either in the aggregate or by the respective subsector panels of experts. At least one trend from each subsector was included; however, for the feedlot production subsector, the two most highly rated trends were excluded because the Environmental Protection Agency's point-source control programs do or will cover the environmental effects of these trends. Hence, the third-ranked feedlot trend, residuals disposal, was selected for this analysis.

As was shown in Exhibit II-1, above, the crop production subsectors (nonirrigated and irrigated) generally have the production-related trends with the greatest environmental implications; consequently, the emphasis of this assessment is on the crop production subsector environmental and ecological effects. Obviously, however, further assessments of additional trends from all subsectors of agriculture are possible and relevant.

1. Runoff and Erosion Control (1)

A total of five subtrends were evaluated as components of the runoff and erosion control trend. Three of these, contour farming, terraces and grass waterways, and use of winter cover crops are recognized methods of stabilizing soil. Optimizing time of farm operations and the use of narrow rows are also considered as erosion control practices. The basic principle behind all five of these practices is that they impede runoff and retard sediment movement. The ecology workshop's ratings for each subtrend are summarized below and are followed by a discussion of each subtrend's extensiveness of use, environmental factors, ecological effects and research needs.

Exhibit II-2. Summary of selected Phase II trends and subtrends in agriculture

Trend	Subtrend
Crop Production	
1. Runoff and Erosion Control	1.1 Contour farming/contour strip cropping
	1.2 Terraces and grass waterways
	1.3 Optimizing time of operations
	1.4 Narrow rows
	1.5 Winter cover crop
2. Conservation Tillage	2.1 No-tillage
	2.2 Reduced tillage
3. Improved Water Application	3.1 Furrow basins
	3.2 Land grading
	3.3 Sprinklers
	3.4 Recycling and controlling tailwater
	3.5 Irrigation scheduling and efficiency
4. Improvement Seed and Plants	4.1 Weather resistance
	4.2 Salt resistance
	4.3 Production efficiency
	4.4 Disease and insect resistant
5. Scouting and Integrated Controls	5.1 Surface scouting
	5.2 Remote sensing scouting
	5.3 Integrated controls
6. Development of New Biological and Chemical Pesticides	6.1 Micro-encapsulated
	6.2 Systemic pesticides
	6.3 Surfactants for herbicides
	6.4 Bio-degradable pesticides
	6.5 Alternative formulations
	6.6 Juvenile hormones
	6.7 Pheromones
	6.8 Sterile males
	6.9 Predators and parasites
7. Methods of Nutrient Application	7.1 Foliar application
	7.2 Multiple application
	7.3 Fall application
	7.4 Liquid fertilizer
	7.5 Aerial and floater application
	7.6 Improved nutrient placement
	7.7 Irrigation application
8. Soil Plant Analysis	8.1 Soil plant analysis
Feedlot Production	
9. Alternative Residual Disposal	9.1 Off-site disposal- solids and liquids
Range and Pasture Management	
10. Grazing Practices and Stocking Rates	10.1 Continuous grazing
	10.2 Specialized grazing
	10.3 Complementary forage seedings
	10.4 Controlled livestock grazing

Subtrend	Aquatic		Terrestrial		Human Health	
	1985	2010	1985	2010	1985	2010
	(Index Rating)*					
1.1 Contour farming/contour strip cropping	+1	+4	+1	+3	0	0
1.2 Terraces and grass waterways	+1	+3	+1	+3	0	0
1.3 Optimizing time of operations	+1	+1	+1	+2	0	0
1.4 Narrow rows	0	+1	0	+1	0	0
1.5 Winter cover crops	0	+1	0	+1	0	-1

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor and 5 = major

Contour Farming/Contour Strip Cropping (1.1)

With this subtrend, farming operations are performed according to land elevations. Strip cropping allows strips of grass, close-growing crops, or fallow to alternate with cultivated crops on the contour.

Extensiveness - In 1964, 20,250,000 acres of grain and row crops were farmed on the contour. By 1969, extensiveness had dropped to 14,570,000 acres, a 25 percent decrease. Further decreases in crops farmed on the contour were estimated for 1976. However, based upon evaluation workshop ratings (Phase I, Volume 1), contouring was expected to increase in use from moderate levels in 1976 to major levels by 2010. This projected increase results from anticipated non-point source controls to maintain and/or achieve water quality standards by the implementation of certain management practices such as contour farming.

Environmental Factors - Productivity of contoured land will be comparable to straight row farming. Fertilizer, herbicide, and insecticide use patterns will not change with contour farming.

Soil loss will be reduced an average of 30-50 percent with contouring alone on moderate slopes. On steeper slopes or on land with topographic limitations, contouring will be much less effective in reducing soil loss. Nitrates and phosphorus will also be reduced in surface water, but the reductions may not be proportional to soil loss reductions. Pesticide residues will be reduced in surface water, but these reductions will, also, be less than those for soil and perhaps less than those for nutrients.

Losses of nitrates and pesticide residues into ground water are not likely to be decreased significantly with contouring.

Ecological Effects - Contouring will have beneficial aquatic and terrestrial effects. These effects will be minor in 1985 because the extensiveness of use for contouring (over 1976 use) will not have increased significantly. The effects will, however, be moderate for aquatic and important for terrestrial by 2010 as extensiveness does increase. Decreased turbidity in the aquatic environment will lead to greater species diversity. A reduction in pesticide residues in surface water will also have a positive effect on aquatic life. The positive effect will increase with the anticipated use of less persistent pesticides in the future. The terrestrial effects will also be beneficial since topsoil losses are reduced, nutrient cycles are retained, and soil will be maintained in a better condition. Based upon present knowledge, pesticide residues at present levels in the nation's surface water are not known to be hazardous to humans. Thus, reductions in pesticide residues with contouring will have no significant effect on human health. Should future considerations of pesticide residues in surface water result in these residues being considered a potential human health hazard, then the human health effects from contouring would be beneficial.

Research Needs - Additional research is needed to determine the effectiveness of contouring on reducing nutrient and pesticide losses. Limited data are available from specific experiments, but more are needed to determine losses from different soil types and different pesticide and nutrient formulations. Research on the potential dangers of pesticides to human health should be continued.

Terraces and Grass Waterways (1.2)

Terraces are soil embankments constructed across a slope to control erosion by diverting or storing surface runoff. Natural or constructed grass waterways are also used to conduct surface water from cropland.

Extensiveness - In 1969, 16,430,000 acres (approximately 6%) of cropland had terraces. In 1976, terrace use was estimated to have neither increased or decreased significantly from 1969 use. While terraces and grass waterways were not important in irrigated crop production in 1976, they will increase to minor levels of use by 2010. Use of terraces in nonirrigated crop production will also increase by 2010, but it is not likely to be as extensive as contouring.

Environmental Factors - Some terrace and grass waterways land will be taken out of production, but cropping intensities per cropped acre and on slopes will increase. Thus, overall productivity will remain unchanged. In general, fertilizer, herbicide, and insecticide use patterns will not change significantly. Fertilizer use could increase slightly on a per acre basis if production per cropped acre is expected to increase to compensate for land taken out of production by terraces. Additionally, the incidence of predators and pests could increase with terrace or grass waterway cover area. This would require an increased use of pesticides in some areas.

Terraces and grass waterways are more effective than contouring in controlling sediment loss and surface runoff. While contouring reduces soil loss 30-50 percent, reductions with terraces are usually expected to be greater. Reductions in nitrate, phosphorus, and pesticide losses will also tend to be greater for terraces and grass waterways compared to contouring, since both surface runoff and soil loss are less. Based on limited research, nitrates in ground water may also be reduced with terrace systems. Pesticide loss in ground water will remain unchanged or decrease slightly (compared to conventional farming techniques).

Ecological Effects - While terraces and grass waterways are usually more effective in runoff and erosion control than contouring, extensiveness of use is lower for terraces. For this reason, the intensity of ecological effects of terraces is comparable to that for contouring; minor aquatic and terrestrial effects in 1985, and moderate aquatic and terrestrial effects in 2010. Beneficial aquatic effects result from decreased turbidity and pesticide residues and increased species diversity. Water will also be conserved with terrace systems. Terraces and grass waterways have increased vegetative cover, creating greater wildlife species diversity, wildlife habitat, and natural pathways for animal populations to travel. These terrestrial effects will be minimized if terraces and waterways are kept mowed or are farmed.

Additional terrestrial effects include retention of topsoil and nutrient cycles and preservation of soil integrity. No significant human health effects will result from this subtrend, since pesticide residues at present levels in surface water are not considered a human health danger. Sediment does contain bound organics. With large reductions in sediment, the increased organics could cause an unpleasant taste or odor in drinking water. However, this potential problem would be one of economics not human health.

Research Needs - Since large reductions in water sediment could increase the relative concentration of organics and degrade drinking water quality, sediment standards for drinking water may need to be developed. Research data are needed to compare the effectiveness of alternative soil erosion measures in controlling nutrient losses. Research and public education are needed to determine the best maintenance management of terraces and grass waterways for wildlife habitat.

Optimizing Time of Operations (1.3)

With this practice, farming operations are performed to minimize the time that the soil is bare. For most areas, this means a change from fall plowing to spring plowing.

Extensiveness - The number of cropland acres plowed in the spring in 1976 is not known, but the tendency for farmers to spring plow and plant earlier was judged to be increasing. Extensiveness was estimated at a moderate level in 1976 and will increase to an important level by 1985. Use should remain fairly constant between 1985 and 2010.

Environmental Factors - In some areas yields per acre will be increased with proper timing of operations, but in other areas, a wet spring may extend tillage-planting operations beyond optimum dates, resulting in lower yields. Thus, overall productivity is not likely to be significantly changed with this subtrend. Fertilizer herbicide and insecticide use patterns are expected to remain unchanged.

The optimizing of pesticide applications to avoid significant runoff from excessive rainfall events will be facilitated by more sophisticated weather forecasting methods. It is anticipated that such eventual sophistication by 2010 will greatly enhance application timing and significantly reduce losses and improve pesticide effectiveness.

Spring plowing will reduce soil loss in most areas, but reductions will be very dependent upon previous crop, soil type, climate, and topographical limitations. Average reductions for soil loss based on limited research findings are estimated at 10-20 percent. Crop residues remaining through the winter can further reduce soil losses. Nutrients and pesticide residues in surface water are expected to remain constant or decrease slightly. This subtrend will have no significant effect on nitrates and pesticides entering ground water, although spring plowing compared to fall plowing may increase vertical nutrient movement.

Ecological Effects - Small decreases in sediment and turbidity will have minor beneficial aquatic effects in 1985 and 2010. Terrestrial effects tend to be two-fold with this subtrend. The land will benefit from retention of topsoil and nutrient cycles. Wildlife will have increased winter food supply and a more structured winter environment when plowing is done in the spring and not the fall. Terrestrial effects will be minor in 1985, with limited effects in 2010. Since nutrients and pesticides in surface and ground water will not be significantly reduced with optimum timing of operations, human health effects will not change significantly.

Research Needs - Continued research is needed to evaluate the effectiveness of management practices as optimizing time of operations, in controlling soil loss and reducing nutrients and pesticides in the nation's waters. The development of more efficient farm implements would allow for speedier spring tillage - planting operations and reduce the necessity of fall plowing for spring plants.

Narrow Rows (1.4)

With narrow rows, the distance between adjoining rows of seeded crops is reduced and the number of plants per acre is increased. Corn and soybeans are especially adaptable to this practice.

Extensiveness - Since 1973, 25 percent of the farm operators in certain corn producing areas have switched to narrow row corn. Narrow row crop production was estimated at moderate levels for 1976 and expected to increase to major levels by 2010. Currently this practice is applicable to corn and soybeans.

Environmental Factors - Overall productivity on a per acre basis will increase with narrow rows. These increases could average 10-20 percent depending upon type of crop, soil conditions, climate, and other crop management practices. Fertilizer and herbicide use will increase with the use of narrower rows. More plants per acre will increase the total fertilizer requirement as much as 30-40 percent to meet the needs of the crop. However, only slight increases in herbicide use are anticipated; and insecticide use will not change with this practice.

Narrow rows will not only provide more cover for the land, but will provide the cover more quickly. This will reduce the amount of soil loss, especially during the first two months of a crop year, but average reductions that can be expected are not documented. Although fertilizer use increases, the number of plants utilizing the nutrients also increases, so total nutrients in surface water will probably not increase and could decrease slightly. There will be little effect on concentrations of pesticides in surface water or on nitrates or pesticides concentrations in the ground water.

Ecological Effects - Narrow row practices will have no significant ecological effects in 1985, and only minor beneficial aquatic and terrestrial effects in 2010. The beneficial effects result from decreased sediment in surface water and retention of topsoil and nutrient cycles on the land. Since nutrient and pesticide concentrations in the environment are not expected to change with narrow row practices, there will be no significant human health effects.

Research Needs - Use of narrow rows is an economical way to increase crop production without increasing environmental effects. Therefore the use and development of other row crops, such as cotton, suitable for narrow rows should be investigated. Optimal use of fertilizers and herbicides with narrow row practices needs to be more fully defined.

Winter Cover Crops (1.5)

Close grown winter cover crops are used to protect and improve the soil between periods of regular crop production. These are grown when there would otherwise be no growing plants or crop residues to protect the soil from erosion and runoff. Cover crops can serve as a second crop in some regions, especially further south, or may be plowed under in the spring for soil improvement.

Extensiveness - Actual acreages of cropland planted with winter cover crops in 1976 are not known but estimated to be minor by the Phase I evaluation workshop (Volume I). By 1985 and 2010, use of winter cover crops will increase to limited levels. In the South, 80-90 percent of the cropland may be planted with winter crops. However, some of this cropland should undoubtedly be classified under double-cropping rather than winter crops grown for cover. In other areas, the agronomic potential for winter cover crops for a second income crop or for soil improvement is substantial, although economic factors are currently marginal.

Environmental Factors - Productivity will vary from region to region depending upon climatic limitations. In the areas where winter cover crops (excluding certain winter row crops grown further south on a double-cropping system) can be used as a second income crop, total yearly production per acre would normally increase. Additionally, winter cover crops can be used for winter grazing of livestock, an economic benefit to the farm operator. However, winter cover crops in some areas with a dry climate or with an unseasonly dry winter and spring will reduce the soil moisture content and cause water stress on the following spring crop.

This could result in significantly lower yearly production per acre especially if the winter cover crop is used for soil improvement and not as a second income crop.

Insecticide use patterns will not change significantly with winter cover crops. Herbicide use per acre may increase slightly, especially if a no-till crop will follow in the spring. Fertilizer use will vary with the use of the winter cover crop. If the cover crop is plowed under in the spring, then the nutrients are simply recycled and fertilizer use will increase little or not at all. Significantly increased fertilizer use, up to 100 percent increase, would be required for some winter cover crops grown as a second income crop.

Winter cover crops will tend to give slight to moderate reductions in soil loss and are comparable to leaving stalkly crop residues through the winter. Nutrient loss to surface water will depend upon the additional use of fertilizer. Nutrient levels will be decreased slightly if commercial fertilizer use is not increased, but total yearly nutrient loss may increase if fertilizer use is greatly increased. Nitrate leaching into ground water will be reduced without increased fertilizer use but won't be significantly changed with increased fertilizer use. Pesticide losses to surface and ground water should not change.

Ecological Effects - There will be no significant ecological effects from winter cover crops in 1985. In 2010, minor beneficial aquatic and terrestrial effects will result from reductions in soil loss. Increased use of paraquat or similar chemicals could potentially have a minor adverse human health effect in 2010. Direct contact with this herbicide during application is particularly hazardous to humans.

Research Needs - Continued pesticide research is needed to develop effective alternatives to the use of paraquat and other toxic pesticides. Additional research is needed to determine the extensiveness of winter cover crops, associated fertilizer use, and the effectiveness of this practice in reducing soil and nutrient losses.

2. Conservation Tillage (2)

Conservation tillage covers a broad category of tillage methods that require less soil disturbance during seed planting and crop growth than the conventional soil inversions with moldboard plowing. Within conservation tillage, two subtrends, no-tillage and reduced tillage, are included for detailed evaluation. This evaluation includes extensiveness of use, environmental factors, ecological effects and research needs. The ecology workshop rated both conservation tillage practices for possible ecological effects in three areas: aquatic life, terrestrial life, and human health. The workshop ratings are given below:

Subtrend	Aquatic (from decreased sediment)		Aquatic (from increased pesticide use)		Terrestrial		Human Health	
	1985	2010	1985	2010	1985	2010	1985	2010
	(Index Rating)*							
No-tillage	+2	+3	-1	-1	0	0	0	0
Reduced tillage	+2	+3	-1	-1	0	0	0	0

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor and 5 = major.

No-till (2.1)

With no-till farming, seeding is performed without tillage preparation and the crop is not cultivated during the production period.

Extensiveness - In 1976, 7.5 million acres were under no-till farming compared to 3.3 million acres in 1972. In 1977, nearly 8 million acres (2.6 percent of cropland total) will be no-till farmed. Although this practice is expected to increase to 2010, current projected estimates (55 percent no-till in 2010) seem high. It seems likely that extensiveness may be only 10-20 percent by 2010.

Environmental Factors - Productivity values are variable, with both increases and decreases found with no-till practices. The type of crop climate, and soil type and condition will determine yields. Not all crops or soils are recommended for no-till farming. Multicropping practices will increase with no-till and increase production on a yearly per-acre basis.

Fertilizer and herbicide use is expected to increase by 15 percent with no-till farming and insecticide use will increase by about 11 percent. Since the fertilizer is not incorporated into the soil, more fertilizer will be required to penetrate the soil and enter the root zone area. Both weeds and pests are increased with no-till.

With conservation tillage methods (no-till and reduced till) an estimated five million acres of fallow land or land with topographic limitations can be brought into crop production. Labor costs to the farm operator are reduced with no-till farming. No-till will also increase the soil moisture content as much as 2 inches per year in some areas.

Substantial soil loss reductions can be expected with no-till. Reductions of 50-95 percent are common. While these large soil loss reductions will tend to reduce nutrient loss to surface water, total available nutrients have increased greatly with this practice. Fertilizer use has increased 15 percent and the fertilizer is surface applied. Crop residues left on soil will also increase the nitrogen content of soil as they weather. It seems likely that nutrients in the surface water will be reduced, but the reductions will be of considerable less magnitude than soil loss reductions.

The effects of no-till farming on pesticide runoff are not well documented. Insecticide use and herbicide use have increased 11 and 15 percent, respectively. Pesticide loss to surface water will be greater for surface-applied compounds that are not incorporated into the soil. The greatest amount of pesticide loss is usually associated with surface runoff, not sediment. Finally, one research experiment found increased herbicide loss with a no-till plot compared to a conventional tilled plot after the first rain effect. Even so, not enough research data exists to predict the effects of no-till farming on pesticide loss. However, it seems that the potential does exist for increased pesticide loss into surface water with no-till.

Nitrates in ground water will show no significant change to small increases. Weathering of crop residues and increased fertilizer use make more nitrate available for leaching. Increased soil moisture content will allow nitrate to percolate through the soil easier and, thus, ground water nitrate concentration could potentially increase. Pesticide loss to ground water will not be significantly changed with no-till practices.

Surface application of some pesticides will result in increased volatilization of those pesticides. The extent of volatilization will be determined by vapor pressure, molecular weight, and other chemical properties of the pesticide.

Ecological Effects - No-till practices will have both beneficial and adverse ecological effects. The large soil loss reductions will decrease turbidity and increase species diversity in the aquatic environment. However, the potential of increased pesticide residues in U.S. waters will have an adverse aquatic effect. By 1985, sediment reductions as a result of no-till practices will have a limited beneficial aquatic effect and a moderate beneficial effect by 2010. Aquatic effects from potentially increased pesticide residues associated with no-till will have a minor adverse effect in 1985 and in 2010.

Terrestrial effects with no-till farming were also beneficial and adverse. Retention of top soil, continued nutrient cycles, and enhanced soil condition and structure will benefit the land. Crop residues left through the winter provide winter food and habitat for wildlife. However, increased pesticide use needed with no-till will have direct and indirect adverse effects on non-target organisms. Terrestrial effects were given a zero rating in 1985 and 2010, not because important ecological effects will not be present with no-till, but because the beneficial and adverse effects will tend to cancel each other.

Although no-till could increase pesticide levels in surface water, the ecology panel felt the levels would still be within the established human safety limits. Since ingestion of pesticide concentrations within these limits by humans is believed to have no harmful effects, there are expected to be no known significant human health effects in 1985 or 2010.

Research Needs - With no-till practices, optimum fertilizer and pesticide use practices should be established. The relationship of no-till, increased pesticide use, and concentration of pesticide residues in surface water run-off needs to be fully researched to help identify potential ecological effects. Continued research is needed for the development of efficient, less-persistent pesticides and effective pesticide alternatives. Support and public education will be needed for the implementation of these newer pesticides and pesticide alternatives.

Reduced Tillage (2.2)

A number of tillage methods are classified as reduced tillage. These involve limited preparation of soil for planting and use of chemical compounds for weed control. The total field surface is still worked but with tillage methods other than moldboard plowing. Crop residues are usually retained on the surface and/or mixed into the top soil.

Extensiveness - In 1972, 26.3 million acres were reduced-tilled compared to an estimated 58.8 million acres in 1977. An additional 40 million acres could be classified as less-tilled by 1977. This would include cropland which is chisel plowed, disced once instead of twice, and planted in rough, trashy ground. By 2010, a significantly large increase is expected for reduced tillage practices. The practice will be major in extensiveness and could include up to 50 percent of all cropland.

Environmental Factors - With reduced tillage, crop yields are comparable and often slightly higher than yields from conventional tillage. Multicropping practices increase with reduced tillage and would increase yields on a yearly per acre basis.

Since fertilizer nutrients must penetrate the soil and travel down to the crop root zone, fertilizer use will increase with this practice. However, reduced tillage involves more soil preparations and the fertilizer increase should not be as great for this practice as for no-till (15% increase in fertilizer use). Herbicide use will also increase for weed problems are more serious with reduced tillage compared to conventional tillage (however weed problems are less with reduced tillage than for no-tillage). Insecticide use could increase as much as 8-9% for this practice. Crop residues left on the soil will increase the incidence of pests.

An additional 5 million acres of fallow land or land with topographical limitations could be shifted to agriculture production with conservation tillage methods (no-tillage and reduced tillage). Reduced tillage will lead to increased soil moisture content in some areas. Farm operators will have reduced energy and labor needs with this practice.

Soil loss will decrease with reduced tillage farming, but the effectiveness will depend upon the amount of residues left on the surface, surface roughness, and the amount and type of reduced tillage used. Reduced tillage is less effective than no-tillage in the control of soil loss. (Note: one research experiment indicates that average soil loss reductions may only be 14 percent when including all reduced tillage methods.) Total nutrients in surface water will probably be reduced, but reductions will not be proportional to the reductions in soil loss.

As with no tillage, the effect of reduced tillage on pesticide loss to surface water is not well documented. Pesticide usage increases, loss to surface water is greater for surface-applied pesticides, and greater amounts of pesticide residues are lost in runoff water than with sediment. Potentially the amount of pesticide entering surface water could increase with reduced tillage. However, this is not proven, and reduced tillage may, in fact, little affect either the increasing or decreasing of pesticide losses into surface water.

Pesticide levels in ground water will not be significantly changed with reduced tillage. No change to slight increases could occur in nitrate leaching since more fertilizer will be applied, crop residues will add to soil nitrate content, and increased soil moisture will facilitate nitrate movement through the soil.

Some pesticides will have increased volatilization losses when surface applied. The amount of volatilization will depend upon vapor pressure, molecular weight, and other chemical properties of the pesticides. The increased loss of pesticides to the air with reduced tillage would probably be small, since other tillage methods may also use surface application of pesticides.

Ecological Effects - The ecological effects of reduced tillage are the same as those for no-tillage, both beneficial and adverse. Reduced tillage is less effective than no-till in controlling soil loss, but will be used more extensively in 1985 and 2010. Aquatic effects are divided into two categories--those from reduced sediment and those from pesticide residues in water. Limited beneficial aquatic effects result from decreased sediment, decreased turbidity, and increased species diversity in 1985. In 2010, these effects will be moderate. The possibility of increased pesticide residues in surface water will cause minor adverse aquatic effects in 1985 and 2010. Terrestrial effects are also beneficial and adverse. Land will profit from the retention of top soil and nutrient cycles. Crop residues through the winter will provide winter food supplies and habitat for the wildlife. But increased pesticide usage will have direct and indirect adverse effects on non-target organisms. Overall terrestrial ratings are zero for 1985 and 2010, because the beneficial and adverse effects tend to balance each other out.

The ecology panel felt that if pesticide residues in surface water remained the same or increased slightly with reduced tillage, the levels would still be within the established human safety limits, and that human health effects would not be significant in 1985 and 2010. If pesticide residues are found to increase more than indicated, then adverse human health effects could result.

Research Needs - Optimum fertilizer and pesticide use with different reduced tillage systems needs to be determined. Further investigation is needed to determine the effect of reduced tillage and increased pesticide use on pesticide losses to surface water. Additionally, research should continue on the development of efficient, less-persistent pesticide and effective pesticide alternatives.

3. Improved Water Application (3)

The improved water application trend reflects a movement in irrigated crop production toward the conservation of water resources and the improvement of irrigation efficiency with the use of existing irrigation systems, better management practices, and professional irrigation scheduling. Of primary concern, is the effect of improved water application methods on the quality of return flows and on soil salinity. Five subtrends were evaluated as improved water application practices. Ecological ratings for each subtrend's impact on aquatic life, terrestrial life and human health are shown below.

Subtrend	Aquatic		Terrestrial		Human Health	
	1985	2010	1985	2010	1985	2010
	(Index Ratings)*					
3.1 Furrow basins	-2	-3	-2	-3	-1	-1
3.2 Land grading	-1	-1	-1	-1	0	-1
3.3 Sprinklers	-1	-2	-1	-1	0	0
3.4 Recycling and controlling tailwater	+2	+3	-1	-1	+1	+1
3.5 Irrigation scheduling and efficiency	+1	+1	0	+1	0	0

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor and 5 = major

A complete discussion of each subtrend follows.

Furrow Basins (3.1)

Small channels or furrows are constructed to carry irrigation waters down or across the slope of fields with this practice. Furrow irrigation does not wet the entire surface but allows the water to seep through the sides and bottom of the channel to provide the necessary moisture to the crop.

Extensiveness - In 1969, 50 percent (19.2 million acres) of irrigated cropland used furrow type irrigation, but the extent of use in 1976 is not known. The flat regions of the West use furrow irrigation more than other areas.

Environmental Factors - Yields from irrigated croplands were 11 percent higher in the East and 38 percent higher in the West than U.S. average yields in 1969. However, it is estimated that salinity reduces crop production on a fourth of all irrigated land in the Western United States and that it presents a potential hazard to one-half of the irrigated acres in the West. Productivity from irrigated cropland may decrease if salinity continues to build in these areas.

Fertilizer, herbicide, and insecticide use with furrow basins are comparable to other irrigation methods. Furrow irrigation uses an average of 2.06 acre feet of water per acre compared to an average of 1.39 acre feet of water per acre for sprinkler irrigation. Efficiency of furrow irrigation is lower than that of sprinkler or subsurface irrigation methods. The average efficiency for furrows is only about 35 percent.

With furrow basins, certain management practices must be followed to reduce sediment and associated pollutants (nutrients, pesticides, and salts). These practices are listed below.

1. The slope of the furrow in the direction of water movement should not exceed 2 percent. With some soil types and in climates with intense rainfall, the slope should even be less than 2 percent.
2. Land grading is essential with furrow basins.
3. Furrow basins should be used on soils with low infiltration rates.
4. Furrows should not be used on steep or rough terrain. (See #7)
5. Water should be applied at a slow rate.
6. Ideally, the amount of irrigation water applied should be measured.
7. Benched, contoured, or diagonal furrows can be used on uneven terrain or with land that may be too steep for straight furrows.

These management practices will tend to reduce pollutant losses with furrow irrigation in many areas. However, with some lands, it is nearly impossible to reduce sediment in furrow irrigation to the extent sediment and associated suspended solids in return flow will meet water quality standards. In general, sediment and other pollutant losses are greater for furrow irrigation than for sprinkler or subsurface methods. Scheduling irrigations, lining of conveyance ditches and furrow drops, and improved drainage facilities could be used with furrow basins to increase efficiency and further reduce pollutant losses.

Significant ground water pollution occurs with furrow irrigation use. Nitrates and other salts become concentrated in ground water entering rivers. It is doubtful if improved furrow irrigation management will significantly reduce ground water pollutants without irrigation scheduling and improved irrigation facilities (lining of conveyance ditches and furrow drops, improved drainage and catch facilities, etc.)

Salinity buildup tends to be greater for furrow irrigation. Not only is the water less efficiently used, but also, salts tend to concentrate in the surface, in the center of beds, and at the highest points in the fields with furrows.

Ecological Effects - Furrow irrigation will have limited adverse aquatic effects in 1985 and moderate adverse aquatic effects in 2010. These effects are the result of sediment, nutrients, pesticide residues, and salts which will enter U.S. waters through surface and ground water from furrow-irrigated land. In evaluating the aquatic effects of furrow basins, it was assumed that return flows would not be adequately controlled and that surface and ground water from irrigated land will enter U.S. rivers. With adequate control of return flow, these adverse effects could be significantly reduced.

The land will suffer with furrow irrigation use if soil salinity continues to be a problem. In 1985, furrow irrigation will have limited adverse terrestrial effects and in 2010, moderate adverse effects.

Concentrations of salts in U.S. rivers where irrigation is practiced have increased over the past two decades and will continue to increase in the future. Drinking water quality has been and will be further degraded. Nitrate concentrations in water will continue to increase and could present potential future human health dangers. For these reasons, furrow irrigation will have minor adverse human health effects in 1985 and 2010.

Research Needs - Continued research is needed in irrigation methods, irrigation facilities, and control of return flows to determine how these can be used to help achieve water quality standards and reduce soil salinity. The feasibility of water renovation programs and cost incentives needs to be more fully investigated if water quality standards cannot be met by irrigation best management practices. With the increase of saline waters in the West, the effects of salinity on human and animal health should be fully researched. A productive and economic use for return flows is needed.

Land Grading (3.2) [1/]

Land grading is the leveling of the land's surface for better movement of water over the land or for soil erosion control. In this discussion, land grading will be evaluated only as an irrigation practice for improved water application.

Extensiveness - Land grading is used most often in irrigated crop production in conjunction with basin, border, or furrow irrigation methods. Actual extensiveness of use in 1976 is not known, but land grading was assessed by the irrigated crop production panel (Evaluation Workshop, Volume I), as having important use in 1976 and increasing to major use by 1985 and 2010.

[1/] Land grading was not originally defined by the Contractor and was added to runoff and erosion control subtrends by the irrigated crop production subsector. However, a more appropriate place for analysis seemed to be with other subtrends specifically designated as important to irrigated crop production, i.e., within the improved water application trend.

Environmental Factors - Productivity can increase with land grading in irrigated crop production as water will flow through the irrigation channels more uniformly. Land grading will help prevent water logging and high spot salinity areas in a field. Increased yields can be signifcant if the irrigated terrain was previously very rough and uneven.

Irrigation water needs can be reduced up to 40 percent on some rough terrain. With terrain that is already flat, water needs may not be significantly reduced. Decreased water use will also slightly reduce soluble fertilizer requirements. Herbicide and insecticide use patterns will not change with land grading.

Elimination of excessive water applications through the use of land grading will reduce soil, pesticide, and nutrient losses to surface water. However, these reductions will not reduce these pollutants to a level that return flows will meet water quality standards.

Slight reductions are expected for nitrates, salts and pesticide levels in ground water with the use of land grading to reduce excessive water application. With terrain that is already nearly flat, pollutants in ground water will not be significantly reduced.

Land grading will reduce high spot soil salinity areas in irrigated cropland. Overall soil salinity will decrease very little unless water requirements are significantly reduced.

Ecological Effects - Land grading was evaluated by the ecology workshop as a practice that would be used with furrow irrigation. The practice will be beneficial to irrigated agriculture by reducing the adverse effects of furrow irrigation. Salt will still enter the river systems and salt concentrations in these rivers will increase with time. For this reason, land grading will have a minor adverse aquatic effect in 1985 and 2010. Salinity in soil will still occur with land grading, but won't be as great for this practice as with furrow irrigation alone. Thus, minor adverse terrestrial effects will result in 1985 and 2010. Potential nitrate levels will also increase in rivers receiving irrigation return flows via surface and ground water. This potential for increasing nitrate levels will have a minor adverse human health effect in 2010.

Research Needs - Research needs for land grading are the same as those for furrow irrigation -- continued research on efficiency, management, and for alternative irrigation methods to meet water quality standards and to control soil salinity.

Sprinklers (3.3)

With sprinkler systems, irrigation water is uniformily distributed to the crop as spray.

Extensiveness - In 1969, 7.2 million acres (18.8 percent of all irrigated cropland) used sprinkler irrigation. Extensiveness of use of sprinkler irrigation in 1976 is not known, but it is expected to have increased since 1969. Although further increases in use are expected for sprinkler systems in the future, depletion of ground water supplies will tend to limit their use in some areas, especially in semi-arid regions of the West. Increased use for optimizing crop quality, as well as quantity, can be expected in the East and upper Mid-West.

Environmental Factors - In 1969, yields from irrigated cropland in the West were 32 percent greater than the U.S. average. In the East, yields were 11 percent higher than U.S. averages for irrigated cropland. While these figures include irrigated crop yields from all methods of irrigation, productivity from a single method, such as sprinkler, will show comparable results. Currently crop production is reduced on one-fourth of the irrigated acres in the Western U.S. due to soil salinity. Overall productivity from land that is kept as irrigated cropland will continue to be high, but some land will be taken out of production as salinity increases above the crops tolerance.

Additionally, sprinkler irrigation in some Western areas may have only highly saline waters available for irrigation use. This can leave toxic, often lethal deposits on crop foliage. Nor are all crops suitable to sprinkler irrigation methods. Certain crops are very susceptible to fungi and have increased incidence of fungi infections from the high moisture conditions of sprinkler irrigation.

Fertilizer, pesticide, and insecticide use with sprinkler irrigations are comparable to their use in other irrigation methods. Sprinkler irrigation requires an average of 1.39 acre feet of water per acre, considerably less than furrow irrigation water requirements (an average of 2.06 acre feet of water per acre). Efficiency of sprinkler irrigation averages 50-60 percent.

Soil, nutrients, and pesticide losses to surface water are, generally, less with sprinkler irrigation methods than with furrow methods. Application rates and the amount of water applied can be more closely monitored with sprinkler systems. These will tend to reduce excessive water applications, and, thus, reduce runoff and erosion. Little data is available on the quantification of pollutants entering surface water from sprinkler irrigated land. With some management practices and soil types, pollutants could probably be significant.

Ground water pollution also tends to be less for sprinkler irrigation than for furrow irrigation. However, use of sprinkler irrigation cannot be relied upon to significantly reduce nitrates, pesticides and salt levels in ground water. Improvement of pollutant levels in ground water with sprinkler irrigation can result with irrigation scheduling and improve irrigation facilities.

Soil salinity is less for sprinkler irrigation than with other surface irrigation methods; however, salinity continues to be a problem in many areas, regardless of the type of irrigation method used.

Ecological Effects - Sediment, nutrient, and pesticide losses to surface water will be less with sprinkler irrigation compared to other surface irrigation methods. This will have a beneficial effect on aquatic life. However, sprinkler irrigation use has seriously depleted ground water supplies in some areas and will continue to reduce these supplies in 1985 and 2010. For this reason, sprinkler irrigation was evaluated as having minor adverse effects in 1985 and limited adverse aquatic effects in 2010.

Minor adverse terrestrial effects in 1985 and 2010 will be found with sprinkler use. Soil salinity will continue to be a problem and wildlife habitat will be destroyed as fence rows are removed to facilitate sprinkler irrigation.

The potential for increased nitrates in surface water is reduced with sprinkler irrigation; thus human health impacts in 1985 and 2010 will not be significant with this practice.

Research Needs - The depletion of ground water supplies should be carefully monitored to determine the seriousness of the problem and to evaluate irrigated agriculture's role in preventing further depletions. The feasibility of using municipal waste effluents in sprinkler systems for agriculture irrigation should be thoroughly investigated. Additionally, continued research is needed to evaluate irrigation methods and the management of and/or the adding of the irrigation facilities necessary to reduce soil salinity and for return flows to meet water quality standards.

Recycling and Controlling Tailwater (3.4)

Only part of the total return flow, tailwater is the excess surface water remaining after irrigation (the rest of the return flow is sub-surface drainage water). Under this practice, tailwater is not allowed to run into rivers and streams but is either diverted to an off-site or is collected in a reservoir or tail ditch for irrigation reuse. Although control of subsurface drainage waters is not actually included in the practice of recycling and controlling tailwater, it is included in parts of this discussion to show how these waters can also affect environmental quality.

Extensiveness - The extensiveness of recycling and controlling tailwater in 1976 is not known. However, as stricter controls are imposed on agriculture point and nonpoint sources of pollution, this practice is expected to increase to help meet water quality standards. Use was estimated to be limited in 1976, moderate in 1985, and important in 2010 (the evaluation workshop, Volume I).

Environmental Factors - Productivity will not increase or decrease significantly with proper management of recycled tailwater. Application of tailwater back on irrigated crops without proper dilution or settling could result in slight decreases in crop yields. With proper management, yields with recycled tailwater will be comparable to yields with water from other irrigation sources. While water that is collected from subsurface drainage systems will require more treatment than tailwater before reuse due to high salt concentrations, limited research data suggests that subsurface return flows are not being recycled for irrigation use, but are diverted to other areas for disposal. Application of such water, however, without treatment could cause significantly large reductions in crop yields in some areas.

Fertilizer, herbicide, and insecticide use will not significantly change with the recycling and control of tailwater. Water use will be reduced with this practice, as much as 30 percent with some methods of surface irrigation. If water use has already been reduced through monitoring the amount of water applied and/or through irrigation scheduling, then water use may be reduced very little with this practice. While installation of tailwater reuse systems will present an initial cost to the farm operator, reuse of runoff water can reduce the ultimate cost of water. Installation of tile drains and collection systems for control of subsurface water will be a more costly operation and will probably not be widely used.

Control of tailwater can significantly reduce the amount of sediment, pesticides, and nutrients entering surface water. The pollutants will be confined to the field where they originated. Control of tailwater will have little or no effect on salt concentrations in surface water. However, control of subsurface drainage waters would reduce the amount of salt that would enter rivers and streams from groundwater. Soil salinity will not be significantly affected with the control and reuse of tailwater. Subsurface drainage systems can be used to control salinity buildup at or near the ground surface.

Ecological Effects - Recycling and controlling tailwater will be beneficial to aquatic life. Reduced sediment, nutrients, and pesticides in water currently receiving surface drainage from irrigated cropland will decrease turbidity and increase species diversity in these waters. Less water will be required for irrigations when tailwater is recycled. In 1985, this practice will have limited beneficial effects on aquatic life and by 2010, with more extensive use of this practice, effects will be moderately beneficial. Control of all return flow, surface and subsurface, would further benefit aquatic life with reduction of salt concentrations entering U.S. waters. However only control of tailwater is included in this assessment, and, additionally, control of all return flow does not currently seem to be a likely development.

Soil salinity will not be controlled with recycling of tailwater. If tailwater is not reused, but diverted to some other receiving area, the potential exists for increased environmental impacts in that area. For these reasons, control of tailwater will have minor adverse terrestrial effects in 1985 and 2010.

Nitrate levels will be significantly reduced in water supplies with the control of tailwater resulting in minor beneficial human health effects in 1985 and 2010.

Research Needs - Continued research is needed on the quality of return flows, their effects on water quality and on economically feasible ways to control return flows. Disposal of tailwater and subsurface drainage waters that are not recycled for irrigation use should be investigated. More public education is needed to inform farm operators that control of tailwater would be beneficial to them as well as to the environment.

Irrigation Scheduling and Efficiency (3.5)

Irrigation scheduling is used to improve efficiency by applying optimum amounts of irrigation water to a particular crop at times when that crop can use the water most effectively. Generally, less water will be applied and less water will end up as return flow with scheduling.

Extensiveness - In 1974, professional irrigation scheduling was used on 382,000 acres of irrigated cropland (approximately 1 percent). Additionally, some farm operators probably used non-professional methods to provide some type of scheduling to their crops. However, these methods are often not as scientific or accurate as professional scheduling. Extensiveness of use was estimated at moderate levels in 1976 by the first evaluation workshop and was expected to increase to major levels by 2010.

Environmental Factors - Increased crop yields and improved crop quality can be expected with irrigation scheduling.

Fertilizer use could be reduced slightly with irrigation scheduling and other irrigation efficiency practices. Herbicide and insecticide use patterns would not be changed with improved water efficiency. Water use will decrease an average of 10 percent with scheduling. Lining of irrigation conveyance ditches can further increase efficiency and reduce water requirements by 20 percent in many areas.

Sediment, nutrient, and pesticide losses to surface water will be reduced with irrigation scheduling. Salt concentrations in surface runoff are comparable to those of the original irrigation water and will not be significantly affected with scheduling.

Salt concentrations in ground water can be significantly reduced with the elimination of irrigation conveyance losses. With irrigation systems that allow uniform, monitored water applications, scheduling can reduce salt loads in return flows, but this reduction is not expected to significantly influence salinity in return flows except where salt buildup is a major factor. Other irrigation systems may not show a decrease in salinity in the return flow with scheduling.

Soil salinity decreases with scheduling, particularly since water use for salt leaching is usually included as part of the practice. Also, with more frequent monitored water application, salt concentrations are not as likely to build up to dangerous levels in the soil.

Ecological Effects - In 1985 and in 2010, irrigation scheduling and efficiency practices will result in minor beneficial aquatic effects from decreased water use. Small decreases in water salinity will also occur in some areas. Terrestrial and human health effects will not be significant in 1985. However, in 2010, terrestrial effects will be of minor benefit since soil salinity will show small reductions.

Research Needs - Continued research is needed on irrigation scheduling and other efficiency practices to help control quality of return flows and soil salinity. Additionally, more public education is needed for the farm operator to recognize the economic and environmental benefits of improving irrigation efficiency through professional scheduling, improved irrigation facilities, and improved irrigation management.

4. Improvement of Seeds and Plants (4)

Improvement of seeds and plants covers a broad area of genetic research in plants. Improved weather resistance, salt resistance, improved production efficiency, and disease, insect, and nematode resistance are four important areas which are analyzed as subtrends within this trend. While research on these subtrends has been continuing for several years, commercial applications are still in their infancy and are classified here as developments rather than current practices. Their assessment is based on the assumption that gradual genetic improvements in resistance and production efficiency will occur by 1985 with further improvements by 2010.

Ecological ratings used in indicating the intensity of ecological effects in three areas, aquatic, terrestrial, and human health are shown below.

Subtrend	Aquatic		Terrestrial		Human Health	
	1985	2010	1985	2010	1985	2010
	(Index Rating)*					
4.1 Weather resistance	0	0	0	0	0	0
4.2 Salt resistance	0	-1	0	-1	0	0
4.3 Production efficiency	0	-1	0	0	0	0
4.4 Disease, insect, and nematode resistance	+2	+4	+1	+3	+1	+2

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects ratings on a scale of 1 to 5, where 1 = minor and 5 = major

Weather Resistance (4.1)

Weather resistance is genetically bred into crop varieties so they will have higher tolerance to heat, cold, drought, and wind. With such developments, agriculture can be expanded in areas that have less favorable growing seasons.

Extensiveness - Improvements in weather resistance have occurred in some field crops. Soybeans with a shorter growing season are being grown in some northern areas of the U.S. Drought tolerant strains of corn and wheat have shown sustained yields in dry years. Gradual improvements will continue to be made with weather resistance in crop varieties, but no major developments are expected in this area in the near future, i.e., weather resistant crop strains that will allow significant year-round cropping.

Environmental Factors - Productivity will increase with weather resistant crops. In years of drought or prolonged cold springs, yields may be maintained with these crops. Crop production could be expanded into areas with more stressful climates, too. Multicropping practices will increase in some areas; however, it is doubtful if year-round cropping will occur throughout most of the U.S. Rather, crops will be developed for normal growing seasons that will be more tolerant of weather stress.

Fertilizer, herbicide, and insecticide use will not change with weather resistant crops in the near future. If major developments in weather resistance made year-round cropping feasible, significantly large increases in fertilizer use and smaller increases in pesticide use would be expected.

Weather resistance crops will not result in any significant pollutant changes in the media, unless multicropping practices and year-round cropping practices increase. Pollutants in the media would also increase with these practices, but extensiveness of these practices (from weather resistant crops) is expected to be very minor in 2010.

Ecological Effects - There will be no significant ecological effects with weather resistant crop varieties in 1985 or 2010. Multicropping practices and crop production on marginal land is not expected to significantly increase with this subtrend; thus, media pollutants will not change significantly either.

Research Needs - Continued research is needed for the improvement of weather resistant crop varieties. The environmental implications of increased multicropping practices with this subtrend should be included in the research.

Salt Resistance (4.2)

With advances in plant genetics, certain crops are being bred to withstand high salt concentrations. These crops could be grown in areas of the U.S. where soil and available irrigation water have become so saline that crop production is impaired or is no longer economically feasible with existing varieties.

Extensiveness - Limited field trials with salt resistant crop strains are encouraging, but commercial use of these crops is several years away. Research with salt resistance continues, with expected use in irrigated crop production before 2010.

Environmental Factors - Productivity in irrigated agriculture will increase with the use of salt resistant crop strains. Irrigated cropland that has become too saline for crop production and allowed to lie fallow, could be brought back into production. Additionally, some salt marsh lands could be used for agriculture.

Fertilizer, insecticide and herbicide use would not be changed with the use of salt resistant crops on existing farm land. Significant pollutant changes in the media are expected only with new or fallow lands.

Ecological Effects - In 1985, no significant ecological effects will result from salt resistant crops. By 2010, commercial use of these crops seems likely, and minor adverse aquatic and terrestrial effects will occur. The use of salt resistant crops will permit cropping on brackish coastline soils, on salt marsh areas, and on fallow saline land. Disruption of the coastline and loss of wildlife habitat on fallow saline land will occur. If significant cropping of brackish coast line soils occurs, the anticipated increase of pesticides and associated runoff into adjacent estuary areas is a probability. Such could have serious consequences in the nursery grounds for shrimp, crab, and many species of commercial and game fish. The unfortunate location of these soils will also result in air borne drift resulting from pesticide application measures.

Production Efficiency (4.3)

Production efficiency in crops result from improved biochemical and genetic control of plant processes. Optimally a plant would be able to utilize nutrients, sunlight, and water more efficiently, and have desirable root development, high yields, and higher quality yields.

Extensiveness - Substantial improvements in agriculture crop production have been made in the past two decades. The improvements largely resulted from a combination of new varieties, high rates of fertilization, high plant populations, disease resistance plants, and control of insects and weeds. While research results will continue to make small improvements in crop production, comparable advances are not likely to be obtained in the future until plant photosynthetic processes can be controlled. This does not seem a likely development by 1985 and is questionable by 2010.

Environmental Factors - Use of crops with improved production efficiency would significantly increase yields and improve quality of yields. However increased productivity from this development will depend upon when and if plant photosynthetic processes can be controlled.

Herbicide and insecticide use would not significantly change with this development. Fertilizer requirements would increase with large changes in production efficiency, especially if the protein content of a crop is expected to be maintained or increased.

Increased fertilizer use could result in small increases in nutrient losses to surface and ground water. While the crop would tend to use nutrients more efficiently during growth, the potential for increased nutrient loss exists immediately after application. No other pollutants changes in the media are expected.

Ecological Effects - In 1985, no significant ecological effects will occur. By 2010, increased fertilizer use could have a minor adverse aquatic effect if major developments have occurred in plant production efficiency. Terrestrial and human health effects will not be significantly changed in 2010.

Research Needs - Continued research is needed for the development of production efficiency in plants. On-going research projects should be monitored.

Disease, Insect, and Nematode Resistent Crops (4.4)

Research in plant genetics has also produced field crops with a high tolerance to disease, insects, and nematodes. Tough stems and stalks, plants with an unappealing taste to insects, and hairy leaves are all genetic developments in crops that reduce losses to disease and insects.

Extensiveness - Nearly 75 percent of agriculture crops have some resistance to at least one type of disease, insect, or nematode. The inbred resistance is often in the form of higher tolerance of a hardier strain, but a crop is rarely ever entirely resistant to all diseases or insects. Research continues to develop more resistant crop varieties to replace those less resistant varieties currently used. By 2010, more crop varieties should be available for commercial use.

Environmental Factors - Resistant crop varieties and improved resistant varieties will continue to increase productivity in the future. Production losses from certain diseases, insects, and nematodes can be substantially reduced with resistant crops.

Fertilizer and herbicide use will not change with resistant crops. Insecticide use will decrease, as highly insect resistant crops become available for commercial use. Since crop resistance is generally insufficient to completely control insects, supplemental chemical insecticide treatments are normally required. However, fewer treatments are needed. There are a few crop varieties that are entirely resistant to insects and have no insecticide requirements.

Insecticide residues in the media will be reduced as more resistant crop varieties are developed and adopted for use. By 2010, reductions in residues could be quite substantial.

In many areas, soil and nutrient losses will not be significantly affected by resistant crops. In areas so affected with disease, insects, or nematodes that crop yields are greatly reduced, resistant crop varieties will provide for better ground cover and for more efficient use of fertilizer. This will cause some reductions in soil and nutrient loss in those areas.

Ecological Effect - Beneficial ecological effects with this development will stem, primarily, from decreased insecticide use. There will be lower levels of insecticide residues in surface water and in aquatic life. Decreased insecticide use would benefit non-target wildlife species which are often exposed to high concentrations during application. With decreased use, there is less chance of direct exposure of toxic insecticides to humans. In 1985, limited beneficial aquatic effects and minor terrestrial and human health effects will result with resistant crops. All effects will increase in intensity by 2010, when crops are expected to be even more resistant to disease, insects, and nematodes and insecticide use will further decrease. Aquatic effects will be important, terrestrial effects moderate and human health effects limited by 2010.

Research Needs - Continued research is needed in the development of crop varieties more resistant to disease, insects, and nematodes. On-going research should be monitored.

5. Scouting and Integrated Control (5)

Two basic practices, subtrends, were analyzed within the trend: scouting and integrated control. Scouting includes both surface scouting and remote sensing. Integrated controls involve the use of biological and/or mechanical treatment in conjunction with chemicals. In 1976, neither of these practices were being extensively used, primarily because the diagnostic and predictive techniques thus far developed and used in scouting have not been reliable. In many cases, damage has occurred by the time pest problems have been identified. Also, although integrated control is not a new concept, many of the biological controls required to make the system effective are still in the developmental stage. While these practices are not in widespread use currently, they will likely become significant factors in crop production in the future.

The ecology panel rated the effects of the scouting and integrated control trend as beneficial generally. Their ecological effects ratings for aquatic life, terrestrial life and human health are as follows:

Subtrend	Aquatic 1985	Aquatic 2010	Terrestrial 1985	Terrestrial 2010	Human Health 1985	Human Health 2010
	(Index Rating)*					
5.1 and 5.2 Scouting-surface and remote sensing	+1	+3	+1	+3	0	+1
5.3 Integrated control	+1	+4	+1	+4	0	+2

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor and 5 = major

Scouting - Surface and Remote Sensing (5.1 and 5.2)

With surface scouting, pests, diseases and potential crop damage are determined by visual inspection; remote sensing scouting, however, primarily involves the determination of insect populations, diseases and/or crop damage through satellite systems.

Extensiveness - The use of scouting was estimated as minor in extensiveness in 1976, but by 1985 it is expected to become more widely used, particularly in the nonirrigated areas. By 2010, it will be widely used and represent a major factor in crop production.

Environmental Factors - Scouting is not expected to have any significant impact on fertilizer or herbicide use since nutrient requirements will be unaffected and effective weed control will continue to require herbicide applications. Significant reduction in insecticide use can be expected when scouting becomes widespread; consequently, appreciable reductions of pesticide residues in the soil and water are projected by 2010.

Ecological Effects - Scouting is expected to have beneficial effects on the ecological systems because of the reduced pesticide use. Although these effects are expected to be minor in 1985, moderate effects are anticipated by 2010 involving the aquatic and terrestrial systems. With the reduction of insecticide use, less re-entry problems are likely to occur, reducing the health hazards. However, the overall effect on human health is considered to be relatively minor in 2010.

Research Needs - Specific research needs have not been identified although the timeliness and reliability of scouting needs further development. The expanded use of scouting will depend more on education than it will in improvements in specific techniques.

Integrated Controls (5.3)

With integrated controls, chemical, biological, and mechanical treatment methods are combined to achieve control of pests and diseases in crop production. Successful integrated controls depend on natural pest population control, along with a combination of techniques that contribute to the suppression of pest-specific diseases such as resistant crop varieties, sterile insect, attractants, use of predators, or chemical pesticides as needed.

Extensiveness - Some of these methods are in their infancy and are not yet widely accepted or feasible. Consequently, the overall use of integrated controls in 1976 was limited. However, by 1985, use of this system will increase to a moderate level and by 2010, integrated controls should be in major use.

Environmental Factors - Significant reduction can be expected in insecticide use with the adoption of integrated controls. Consequently, reduced pesticide residues can be expected in the soil and water, particularly in 2010, when these systems become widely used.

Ecological Effects - Integrated controls for the most part limit pesticide use to target organisms; consequently, both the aquatic and terrestrial system would be enhanced with the resultant pesticide reduction. However, this enhancement should not become fully apparent until 2010 when the systems come into wide use. Thus, use of integrated controls will have only minor aquatic and terrestrial effects in 1985, but important effects on these two systems by 2010. Human health effects will be limited in 2010.

Research Needs - Research in this area should be supported with education in the benefits of these controls.

6. Development of New Biological and Chemical Pesticides (6)

A total of seven developments or subtrends involving new biological and chemical pesticides were analyzed in the initial environmental assessment. These include:

6.1 Micro-encapulated pesticides
6.2 Systemic pesticides
6.3 Surfactants for herbicides
6.4 Bio-degradable pesticides
6.5 Alternative formulations
6.6 Juvenile hormones
6.7 Pheromones
6.8 Sterile males
6.9 Predators and parasites

Although much is known about systemic pesticides, surfactants, biodegradable pesticides, alternative formulations, predators, parasites, and sterile males, the use of developments in these areas are still in the "field-scale trials" or "limited use" stages and the probability or extent of adoption and the measure of the environmental impacts of the individual developments cannot yet be adequately gauged. Consequently, the ecology workshop combined the developments in their evaluation into two categories: chemical and biological. For this reason, the subsequent discussion covers the trend in those two categories. Also since the developments are largely experimental, the extensiveness is excluded from the discussion. The ratings assigned by the ecology workshop are as follows:

Subtrend	Aquatic 1985	Aquatic 2010	Terrestrial 1985	Terrestrial 2010	Human Health 1985	Human Health 2010
	--------------(Index	Rating)*				
Development of new chemical pesticides	+1	+3	+1	+2	+1	+2
Development of new biological pesticides	+1	+3	+1	+3	+1	+3

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor and 5 = major

Development of New Chemical Pesticides (6.1 - 6.5)

These developments include those of micro-encapulated pesticides, systemic pesticides, surfactants, bio-degradable pesticides, and alternative formulations.

Environmental Factors - The overall amounts of pesticides required are expected to be decreased from those that would be required with existing types of pesticides. Most of the reductions would result from increased efficiencies. The greatest potential reduction would be associated with surfactants with possible decreases in herbicide use by as much as 50 percent. Because of expected reductions in requirements, less runoff into surface waters is anticipated. There would not only be less runoff, but also less toxicity if developments in biodegradable pesticide come into widespread use. A decrease in pesticide residues in the soil (relative to existing pesticides) can be expected with these developments, particularly those of herbicides. However, the full impacts of residues caused by systemic pesticides are not known at this time, especially with nontarget organisms.

Ecological Effects - Beneficial ecological effects can generally be expected with the greatest benefits expected from developments in biodegradable pesticides. Since these pesticides would ideally be selective and less toxic to animals and humans, minor benefits can be anticipated in all ecosystems by 1985. Species diversity would be increased in both the terrestrial and aquatic systems and health hazards would be reduced. By 2010, use of new chemical pesticides is expected to have moderate benefit and aquatic effects and limited beneficial effects on terrestrial life and human health. Although favorable effects can be expected, for the most part, potential problems may exist with the developments in systemic and micro-encapsulated pesticides where persistence may increase.

Research Needs - Research is needed on the environmental effects of chemical pesticides as they are developed including studies of systemic residues and the nature of degradation products. Research is also needed on bio-magnification in the food chain and effects of pesticides in the decomposing food chain.

Developments of New Biological Pesticide (6.6 - 6.9)

These developments include the use of juvenile hormones, pheromones, sterile males, predators, and parasites.

Environmental Factors - Biological pesticides are normally insect specific; consequently, the level of total insecticide use is not expected to decrease significantly as a result of adoption of new biological pesticides. The use of juvenile hormones and pheromones can be expected to leave residues in the water and soil; however, their quantities are too insignificant to be harmful to animals or humans.

Ecological Effects - On a national scale, the benefits of new biological pesticides will be relatively minor with no significant breakthroughs receiving widespread technological applications expected by 1985. By 2010, substantial advancement in these developments can be expected and the ecological effects should be moderate in intensity. Developments are expected to have regional implications where enhancement of regional ecological systems may become significant.

Research Needs - Research is needed in the predator and parasite area to determine the potential consequences of these agents after the target insects have been controlled or eradicated, but present USDA use controls are stringent enough to lessen the theoretical dangers. Research is more importantly needed to further develop and optimize the use of pheromones, juvenile hormones, and host specific bacterial and viral pest diseases.

7. Methods of Nutrient Application (7)

Seven subtrends involving methods of applying nutrients were analyzed. These subtrends, listed below, involve the form in which fertilizer is applied, the timing and frequency of application, and the type of applicators used. Although there is a considerable amount of discussion of these technologies in the literature, very little can be found on their environmental implications. Consequently, environmental factor assessments were based on a limited number of research findings. The evaluations of the ecology workshop are shown below. According to the workshop, the use of foliar applications, liquid fertilizers, and improved placement of fertilizer will have very little change in ecosystem effects. Fall applications were considered to have the most significant effects, and these were expected to be adverse.

Subtrend	Aquatic 1985	Aquatic 2010	Terrestrial 1985	Terrestrial 2010	Human Health 1985	Human Health 2010
	(Index Rating)*					
7.1 Foliar application	0	0	0	0	0	0
7.2 Multiple applications	+1	+1	0	+1	0	0
7.3 Fall applications	-2	-3	0	0	-1	-1
7.4 Liquid fertilizer	0	0	0	0	0	0
7.5 Aerial and floater application	0	0	+1	+2	0	0
7.6 Improved nutrient placement	0	0	0	0	0	0
7.7 Irrigation application	-1	-1	0	0	0	0

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor and 5 = major.

Foliar Application (7.1)

With foliar applications, fertilizer is sprayed on growing plants so that nutrients may be taken up through the leaves of the plant. Foliar applications are primarily used as an adjunct to conventional fertilization.

Extensiveness - This method is currently in an experimental stage with only limited production trials. In 1976, the utilization of this technique was slight and it is expected to increase to minor levels only by 2010.

Environmental Factors - Since nutrient uptake by plants is expected to be more efficient through foliar applications, the expected runoff of nutrients should be less than comparable levels of surface applied fertilizer. However, insufficient data exists to assess the environmental effects of actual trials. Potential drift problems can occur; however, this can be effectively controlled through proper timing of application.

Ecological Effects - No significant change in ecological effects are expected from the slight increase in the use of foliar application.

Research Needs - Research on the technology and agronomic results of foliar application should include an investigation of environmental implications.

Multiple Applications (7.2)

Multiple applications of fertilizer refer to more than one time of application in order to realize optimum growth and crop production.

Extensiveness - In 1976, greater than 40 percent of the cropland received more than one application of fertilizer. This practice is expected to increase significantly by 2010.

Environmental Factors - Multiple applications of fertilizer are generally more agronomically efficient than single applications; consequently, overall fertilizer requirements are expected to be slightly less under this practice than with a single application. In multiple applications, fewer nutrients are available for runoff or leaching. This coupled with the overall reduced fertilizer requirement (when compared to single application) is expected to reduce both nutrient runoff and leaching. An adverse impact on the environment can be expected from a slight increase in soil compaction associated with multiple applications.

Ecological Effects - Multiple applications can be expected to have relatively minor but beneficial effects on the aquatic and terrestrial ecosystems. The reduction in nutrients in the surface water will decrease the potential for eutrophication. Also, the potential for nitrogen leaching will be reduced. Human health will not be significantly affected with this application practice.

Research Needs - Research is required to determine the differential in nutrient runoff and leaching resulting from multiple and single applications.

Fall Application (7.3)

With fall application, fertilizer is applied during the fall season prior to the primary growing season of the crops.

Extensiveness - In 1976, 39 percent of all fertilizers were fall applied. This method of application occurred for the most part in nonirrigated areas. Use will increase slightly by 2010.

Environmental Factors - Because of the fertilizer loss during the winter prior to the growing season, this method of application is less efficient than spring application. Consequently, the increasing amount of fertilizer fall applied will tend to increase the overall fertilizer use. Because of the greater amounts of fertilizer applied and the potential of runoff and leaching during the winter season, nutrient losses to surface and ground water will be increased.

Ecological Effects - Fall application is considered to have the most adverse ecological effects of any of the application techniques analyzed. These occur both in the aquatic system (limited adverse effects in 1985 and moderate effects in 2010) and on human health (minor adverse effects in 1985 and 2010). The increased nutrient runoff will result in increased eutrophication while the increased leaching poses potential problems in nitrate contamination of ground water. No significant effects are expected on the terrestrial system.

Research Needs - Research is needed to determine the regional environmental impacts of fall application.

Liquid Fertilizer (7.4)

Application of nutrients in liquid form is practiced partially as a means of enhancing crop production and also as an efficient method of handling fertilizer material.

Extensiveness - In 1975, 30 percent of all fertilizer applied was liquid. This represents an average annual increase of close to 3 percent over the past seven years. Use is expected to increase significantly by 2010 to major levels.

Environmental Factors - The productivity of liquid fertilizers is generally slightly higher than equivalent solid forms. To a slight extent the overall fertilizer requirement may be reduced when compared to the amount that would be required with the use of solid fertilizer. Since there is no substantial differences in the pollution effect of the two forms of fertilizer, a slight reduction can be expected in the availability of nutrients for runoff and leaching.

Ecological Effects - No significant change in ecological effects is expected to result from the trend towards the increasing use of liquid fertilizer.

Research Needs - On-going research involving liquid fertilizers should address the environmental implications.

Aerial and Floater Application (7.5)

This method refers to fertilizer application by aircraft and by ground vehicles (floaters) equipped with high floatation tires designed to reduce soil compaction and to permit application during wet weather.

Extensiveness - In 1976, an estimated 50 percent of all cropland was traversed at least once with floater vehicles for fertilizer application. Less than five percent of cropland was estimated to have been fertilized aerially. The total cropland having fertilizer applied by either means is expected to increase slightly by 2010.

Environmental Factors - No significant changes are expected in the amounts of nutrients delivered to surface and ground water as a result of the increase in these means of application. A slight decrease in soil compaction can be expected with the use of floaters. A small loss of fertilizers can be expected because of the drift associated with aerial delivery; however, overall this is not expected to be significant.

Ecological Effects - No significant effects are expected on either the aquatic system or human health as a result of the increasing use of these application methods. Floater application will have minor effects in 1985 and limited effects in 2010 which are beneficial to the terrestrial systems from a reduction in soil compaction.

Research Needs - Research is needed to determine nutrient runoff variations associated with alternative application methods.

Improved Nutrient Placement (7.6)

Improved nutrient placement may involve either aerial, water, side band or broadcast applications depending on prior methods and/or time of application during the growing season.

Extensiveness - In 1976, an estimated 30 percent of the fertilizer was applied under improved placement practices. This percentage is expected to increase only slightly by 2010.

Environmental Factors - As a result of improved practices, fertilizer requirements, especially phosphorus, are expected to be slightly less than under conventional practices. The potential also exists for less nutrient loss, both because of a relatively smaller requirement and more efficient nutrient utilization.

Ecological Effects - Although improved nutrient placement has the potential for less nutrient runoff, no significant effects on the ecological systems are expected.

Research Needs - No major environmental effects for research needs have been identified.

Irrigation Application (7.7)

This practice involves the disposition of fertilizer with irrigation water to the crops.

Extensiveness - An estimated 25 percent of all irrigated cropland received applications of fertilizers in irrigation water in 1976. This is expected to increase by 2010 to moderate levels.

Environmental Factors - This method of application facilitates multiple applications and optimal rates and timing of applications, consequently, increased fertilizer efficiency can be expected. Although efficiency increases, loss of nutrients in the tailwater is expected to increase also, but this increase is not expected to be substantial.

Ecological Effects - The increased nutrient loss to tail waters is expected to result in adverse but minor effects on the aquatic system in 1985 and 2010. No significant effects are expected on the terrestrial system or on human health.

Research Needs - Research is needed in determining the amounts of nutrient loss associated with irrigation application, including variations in loss due to alternative irrigation procedures.

8. Soil-Plant Analysis (8)

The ecology workshop assigned ratings reflecting expected effects of soil-plant analysis on ecological systems as listed below. The ± sign indicates that the effects could be beneficial or adverse, depending on what other nutrient management practices occur.

	Aquatic		Terrestrial		Human Health	
Subtrend	1985	2010	1985	2010	1985	2010
8.1 Soil-Plant Analysis	±1	±2	0	0	0	0

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5 where 1 = minor and 5 = major

Soil-Plant Analysis (8.1)

Soil-plant analysis involves monitoring nutrient uptake, soil nutrients available, and plant condition to provide information to adjust fertilizer rates, timing, and cultural practices.

Extensiveness - About a fourth of the cropland under production was covered by some form of soil analysis in 1976 while less than 5 percent was covered by plant analysis. Normally these analyses are conducted once every three years for a specific production unit; consequently the maximum coverage in a given year that could be expected would be approximately one-third of the cropland under production. It is anticipated that the actual coverage in 2010 will be less than 30 percent in any one year.

Environmental Factors - Generally, increased fertilizer application rates can be expected as a result of the conduct of soil-plant analyses. Consequently the increasing trend towards the use of these techniques should increase overall fertilizer use. Although the overall use can be expected to increase, the actual nutrient runoff should decrease because of the efficiency involved. This efficiency would occur from better timing, more effective nutrient balance, and by better meeting plant demands.

Ecological Effects - The effects of the increasing use of soil-plant analysis on human health and the terrestrial systems are not expected to be significant. However, effects on the aquatic system may be beneficial or adverse depending on the other nutrient management techniques used. If proper management is used, runoff will decrease, resulting in an improvement of the system. However, if the expected increases in fertilizer use involve improper management, degradation of the system can be expected.

Research Needs - On-going research designed to improve techniques in soil-plant analysis should include investigations of environmental effects.

9. Alternative Residual Disposal (9)

Alternatives for feedlot waste disposal include storage, on-site utilization and off-site disposal. The most significant change involving the use of these methods is expected to be an increase in off-site disposal; consequently, this is the only alternative analyzed in the study. In its ecological assessment, the workshop assigned the following ratings to reflect the anticipated effects on each of the ecosystems.

Subtrend	Aquatic		Terrestrial		Human Health	
	1985	2010	1985	2010	1985	2010
	(Index Rating)*					
9.1 Off-site Disposal	-1	-2	+1	+1	-1	-1

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*/ Rating Index - Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5 where 1 = minor and 5 = major.

Off-site Disposal (9.1)

Off-site disposal involves land application of both solids and liquids through spreading and irrigation. Application is expected to be made primarily on ranges, pastures and cropland.

Extensiveness - In 1976, about 500 million tons of animal wastes were generated in feedlots. The amount is expected to increase by about 30 percent in 1985 and 70 percent by 2010. Most of the increase will be disposed of through land application. At a typical disposal rate of 40 tons/acre, these incremental increases would require about 4 million acres for disposal in 1985 and 8 million in 2010.

Environmental Factors - Manure generally improves the water holding capacity of the soil and consequently, decreases total surface runoff. Although the total surface runoff is decreased, the concentration of nitrogen and organic material is increased in the runoff. There has been no research which directly relates sediment loss with land application. However, with a reduction in surface runoff, it can be concluded that a reduction in sediment loss would occur. Application of manure can generally be expected to increase soil infiltration and soil nitrogen. This increases the potential for production, but also, the potential for nitrate pollution of ground water.

Ecological Effects - The increase in nitrogen and BOD in surface water can be expected to increase eutrophication and accelerate algae blooms in the surface water with land application. Although the overall effect on the aquatic system is expected to be adverse (minor in 1985 and limited in

2010), the beneficial effect on the terrestrial system is expected to be minor with an enhancement of the soil structure resulting from the increased water holding capacity and the addition of organic matter. The increased soil infiltration rates promote leaching and pose a potential danger of nitrate poisoning in well water. This adverse human health effect is expected to be minor in 1985 and 2010, however.

Research Needs - Research is needed both to determine amounts of pollutants generated with land application at varying rates and to assess ecological effects of this application. Also, the economic feasibility of hauling manure longer distances needs further analysis. Research in the ecological area should include investigation of long-term effects of nitrates on humans, the effects of high sodium content in rations on soil deflocculation, and the rotations required to reduce the effects of copper, arsenic, and sodium in rations.

10. Grazing Practices and Stocking Rates (10)

In Phase I of this study, grazing practices and stocking rates were analyzed as two separate trends. However, because of the interdependence of these practices, the two have been reclassified as a single trend in Phase II. The environmental and ecological effects of these subtrends were evaluated. The initial subtrend includes an examination of the effects brought about by changes in the overall relationships between the two basic grazing systems: continuous and specialized. The ratings assigned by the ecology workshop to each of the subtrends are listed below.

	Aquatic		Terrestrial		Human Health	
	1985	2010	1985	2010	1985	2010
	(Index Rating)*					
10.1 and 10.2 Continuous and specialized grazing	+1	+2	+2	+3	0	0
10.3 Complementary forage seeding	0	0	0	-1	0	0
10.4 Controlled livestock grazing	+1	+1	+1	+3	0	0

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*/ Index Rating = Beneficial (+) or adverse (-) ecological effects rating on a scale of 1 to 5, where 1 = minor, and 5 = major

Continuous and Specialized Grazing (10.1 and 10.2)

As indicated above, this subtrend encompasses the two basic grazing systems being utilized on range and pasture. In continuous grazing, livestock have unrestricted access to any part of the range or pasture throughout the grazing period. In the specialized systems, which include rotation systems, access is restricted during the growing season. In this analysis, the focus is on rangessince the differences of the two systems on pasture is minimized with the annual improvement associated with pasture.

Extensiveness - In 1970 about 750 million acres of range were grazed; 85 percent of this was grazed under the continuous system while 15 percent was grazed under the more intensive specialized systems. By 2010, it is estimated that close to 800 million acres will be grazed, of which 35 percent will be under specialized grazing and only about 65 percent under continuous.

Environmental Factors - In general, the trend towards specialized systems can be expected to increase the basal area, improve the quality of vegetation, and reduce bare areas on the range. Consequently, a reduction in runoff of both sediment and nutrients can be expected. Soil conditions will be somewhat improved from increased infiltration rate and decreased compaction. On the other hand, the increased soil infiltration will increase the potential of nitrate contamination of ground water by leaching.

Ecological Effects - Reduced runoff associated with this subtrend would result in minor beneficial effects to the aquatic system in 1985 and limited effects in 2010. The increased quality and productivity in vegetation would increase the species diversity with limited beneficial effects in 1985 and moderate effects in 2010 on the terrestrial ecosystems. No significant effect on human health is anticipated from the potential leaching of nitrate to ground water because of improved infiltration rates on ranges.

Research Needs - Research is needed to determine the effects of nutrient and sediment runoff under both specialized and continuous grazing systems.

Complementary Forage Seedings (10.3)

This subtrend involves the increasing use of restricted and seeded access plots with the objective of complementing the existing forage, usually before or after normal forages are available.

Extensiveness. Currently this practice is largely in the experimental stage and is expected to have only limited application by 1985. By 2010, it will be in moderate use according to the Range and Pasture Panel (Phase I - Volume I).

Environmental Factors - Productivity in both forage and beef is expected to be enhanced with the adoption of this grazing practice. The improvement in vegetation will result from less pressure on the range from potential overgrazing. This practice can be expected to have both short-term and long-term effects. In the short-term, increased runoff of sediment and nutrients can be expected during periods of renovation and seeding. However, in the long-term, the improved vegetation will decrease the runoff. The overall impact is not expected to be significant. The potential for pollution of ground water will be increased.

Ecological Effects - The overall ecological effect from this practice is not considered to be significant in the near future. By 2010, there may be minor detrimental effects on the terrestrial systems brought about by tame grasses in the seeded plots. The introduced grasses will reduce plant diversity.

Research Needs - This practice is currently in the research stage. As it is developed, research should include environmental effects assessments.

Controlled Livestock Grazing (10.4)

This subtrend reflects an increasing use of stocking rates specifically designed to maintain or improve range conditions. This type of grazing is accomplished under the "proper use" concept.

Extensiveness - In 1970, an estimated 85.7 million acres of range were under exploitive type management and being overgrazed. This amounted to approximately 10 percent of the range being grazed. The goal under the Forest and Rangeland Renewable Resource Planning Act of 1974 is to reduce this to zero by 2000.

Environmental Factors - The increasing use of proper stocking rates or controlled grazing is expected to increase the production and quality of forages on range. This improved vegetation will provide greater ground cover and reduce runoff. Higher infiltration rates can be expected to increase the potential for leaching and contamination of ground water. However, this potential is not considered significant. Soil conditions can be expected to be improved with less erosion and compaction and increased infiltration.

Ecological Effects - Increasing use of controlled livestock grazing can be expected to have beneficial effects on both aquatic and terrestrial systems. However, the effects are expected to be only minor by 1985. By 2010, the effects on the terrestrial system should be moderate as result of increased plant diversity.

Research Needs - A need exists for research on the extent of nutrient and sediment runoff under controlled grazing.

B. Silviculture Sector Trends

Five (5) trends and 16 subtrends, as shown in Exhibit II-3, were selected for detailed analysis within the silviculture sector. The rationale for selection of the trends, with the exception of the number 5 trend, was that each trend was rated as having relatively high environmental implications in the silviculture sector by the Phase I (Volume I) workshop. The number 5 trend was selected because one of its subtrends, clearcutting, has become a highly sensitive and controversial issue with the public.

Trends and subtrends within silviculture have different levels of regional significance and these differences are noted within the discussion sections below. In particular, two of the top ranked subtrends, permanent road construction (1.1) and mechanical site preparation (2.2) are confined almost exclusively to certain regions, i.e., permanent road construction in the Rocky Mountains and Pacific Coast, and mechanical site preparation in the South.

As with the agriculture trends, detailed analysis of silviculture trends-subtrends includes extensiveness of use, environmental factors, ecological effects, and research needs. However, ecological effects of silviculture trends were not determined in a formal workshop setting as were the ecological effects of agriculture trends. Since current literature deals with ecological assessments of different silviculture practices, much of the ecological assessment presented herein required only a detailed review of the literature. Additionally, however, a professional ecologist reviewed the ecological findings and added pertinent information where necessary. The present study of silviculture was largely confined to trends stimulated by technological developments in agriculture and silviculture. Further research should investigate the kinds that reflect national and international economic developments.

Ecological effects were evaluated and rated in five areas for silviculture's subtrends-trends: aquatic life, terrestrial life, human health, recreational opportunity and aesthetics. The recreation and aesthetics effects of silvicultural activities are considered important because they, too, are a part of the composite ecosystem.

1. Access to Timber Resources (1)

Four subtrends are included for detailed analysis in the access to timber resources trend: permanent road construction, project road construction, road maintenance, and road reconstruction. These subtrends are of particular environmental importance in the Western region where terrain is often a limiting factor in road construction.

Permanent Road Construction (1.1)

Permanent roads will be constructed to gain access to yet untapped old virin growth forests, primarily in the West. Once built, these roads

Exhibit II-3. Summary of selected Phase II trends and subtrends in silviculture

Trend	Subtrend
1. Access to Timber Resource	1.1 Permanent road construction
	1.2 Road maintenance
	1.3 Project road construction
	1.4 Road reconstruction
2. Site Preparation	2.1 Log extraction
	2.2 Mechanical preparation
	2.3 Burning prescription
	2.4 Chemical treatment
	2.5 Fertilizer treatment
	2.6 Soil moisture control
3. Log Extraction	3.1 Harvest unit layout
	3.2 Equipment use and development
4. Utilization	4.1 Extraction residue recovery
	4.2 Minimum size and quality extension
	4.3 Species use enlargement
5. Cutting System	5.1 Clearcutting

will be used continually as collector and feeder roads for the dendritic network of logging spur roads around them.

Extensiveness - In 1976, the total mileage of permanent forest access roads in the U.S. was not known. However, forest roads in the northwest regions of Oregon, Washington, Idaho, and southeast Alaska totaled some 248,000 miles. Considerably fewer permanent forest roads exist in the Rocky Mountains and in the East. Additionally, the private silviculture industry has its own systems of permanent access roads which are not monitored by public agencies.

New construction of permanent access roads is expected, for the most part, to relate directly to the timber sales policy of the National Forest Service (NFS). Current road construction, with the even-flow, non-declining policy of NFS, is about 6,200 miles per year with the completion of all permanent roads scheduled before 2030. Yearly construction is expected to decline through 2010, as the need for permanent access roads diminishes. An estimated 80 percent of all NFS road construction and 100 percent of Bureau of Land Management (BLM) construction will occur in the West. In the East and South, road systems have long been established and construction of permanent roads will be minor.

Environmental Factors - As a result of NFS even-flow, non-declining production policies, construction of permanent roads is not expected to increase annual silviculture production. Should this policy change to meet inflation and the increasing demand for timber products, then the NFS road building program could be accelerated. This would result in road access to far more timber area and volume per year. Permanent roads will remove some commercial forest from production, but production losses will be rather insignificant.

Road construction, depending importantly on regional location, results in soil loss, changes in water quality, water yield, and water flow patterns. The U. S. Environmental Protection Agency has established guidelines for minimizing the environmental impacts of road constructions. Those guidelines include optimum road location for the type of terrain, lower standards for road width and grade, and use of cuts and fills to minimize soil movement. Offsetting the beneficial effects of these practices will be the need to construct roads in areas previously left unlogged. These areas are most often increasingly steep with difficult terrain that does not lend itself to road construction. Although soil losses are usually greater for road construction than for other silviculture practices, better planning and management of road construction in the future will produce less severe environmental impacts. Roads, once constructed and stabilized, should not result in further soil losses.

Pesticide and nutrient loss will not be a factor in road construction. Certain building materials (e.g., asphalt and oil) may be transported from the site via runoff and sediment to receiving surface waters.

Ecological Effects - Construction of permanent roads (and other logging-related roads) will continue to have adverse aquatic and terrestrial effects in 1985 and 2010. These effects are expected to decrease in intensity with better planning of road construction and with the decline in total annual road construction through 2010. Aquatic effects include turbidity, sediment loading, impediment of water flow, and with streamside road construction, thermal pollution with the removal of forest canopy. New edge areas will benefit wildlife, but roads may also disrupt normal wildlife travel lanes and will create a hazard to wildlife crossing such roads. Excessive sedimentation can be destructive of benthic organisms and their living strata, and can destroy trout and salmon spawning areas.

Aesthetic impacts of permanent road construction can be minimized with careful road location with respect to visibility from other viewpoints. However, even with optimum road location, aesthetics will be adversely affected if the road is to virgin areas. Some recreational opportunities will increase with greater access to forests. However, wilderness experiences will be essentially eliminated with road construction into virgin areas. Human health should not be significantly affected with permanent road construction.

Research Needs - More effective planning and management are the key to reduction of the environmental impacts of road construction. Necessary planning includes the development of improved standards. Consequently, research is needed to determine minimum road standards compatible with road use requirements in areas such as cuts, fills, bed width, and ballast.

Road Maintenance (1.2)

Generally, all permanent and project access roads require constant attention to insure that logging traffic is not impeded and that drainage systems are kept free of obstacles. Additionally, access roads currently not in use are periodically checked for damage.

Extensiveness - Extensiveness of road maintenance on timber access roads is not known for 1976, but estimated to be limited. As more permanent and project roads are built, maintenance needs will increase and by 2010 use is expected to reach important levels.

Environmental Factors - Road maintenance will not directly affect silviculture productivity. However, productivity will be indirectly affected if road maintenance is needed before a timber area can be reentered for harvesting. Resource use patterns will not be changed with road maintenance practices.

Road maintenance can potentially increase or decrease soil loss to surface water. Erosion problems will decrease with the increased use of road surfacing, use of mulches or green cover on bared roadway soil, and clearance of drainage canals. Grading slopes back to the original slope conditions will often reduce erosion losses, also. However, grading of unsurfaced roads can cause increased soil loss temporarily. In general, maintenance of a road is considered preferable to no maintenance from the environmental viewpoint.

Ecological Effects - Road maintenance can result in either minor beneficial or adverse aquatic effects depending upon the type of maintenance practice. With some practices, sediment loadings to surface water will temporarily be increased. Clearance of drainage systems and certain other practices will reduce the sediment load.

Effects on the terrestrial ecosystem will be minimal. Proper drainage flow and surfacing of roads will reduce soil erosion losses.

Aesthetic values will not be significantly affected by road maintenance. Recreational and wilderness opportunities will be increased to the extent that passages to recreational areas are open. Human health effects are not a significant factor with road maintenance.

Research Needs - Research is needed in the development of equipment designed to minimize soil disturbance.

Project Road Construction (1.3)

Project roads are built solely to gain access to a certain area for harvesting purposes. After harvesting, these roads are abandoned or retired with the idea that they can be reopened at a later date.

Extensiveness - Extensiveness of project road construction in 1976 was estimated to be moderate and expected to increase slightly by 1985 with a decrease back to a moderate level of use by 2010. The peak in 1985 will result from expected increased harvesting activity on private and federal forests in the West, requiring the construction of access roads, either permanent or project. In general, each square mile (640 acres) of timber harvested requires about 5 miles of road access but this amount varies with the harvesting system and local forest conditions.

Environmental Factors - As with permanent access roads, project roads will not directly affect annual timber production based on current NFS policies. Project roads will only provide access to resources so that harvesting can occur.

Project road construction has the same environmental implications as permanent road construction, primarily increasing soil loss. However, soil loss could be greater for project roads in that these roads may not be so carefully engineered as permanent roads. Additionally, project roads that are not surfaced will tend to have greater soil loss. Properly engineered project roads do have the potential to be reconverted to vegetative growth or even timber (although compaction will reduce soil quality in that road area). Thus, soil loss with project roads is often temporary, occurring only with harvesting activity and until the area is revegetated.

Ecological Effects - Again project roads present the same ecological effects as permanent roads, but with the potential for recovery with revegetation. The aquatic ecosystem will experience increased turbidity, sediment loading, altered water-flow patterns, and occasionally thermal pollution when roads are placed too close to streams.

While soil erosion will be increased (often temporarily) and wildlife habitat and travel lanes disrupted, project roads will ultimately benefit some wildlife species. On road abandonment, a new succession of wildlife will enter the area as revegetation occurs. Increased edge will increase species diversity. Revegetation will provide more forage for elk and deer. As canopy and overstory close over the abandoned roads, these effects will diminish.

Project roads are less in sight of traffic and temporary, so that their aesthetic effects will tend to be minimal. There will, however, be non-pleasing visual experiences with some project roads.

Recreational opportunities, as hunting and wildlife viewing, will increase with project access roads. Again, wilderness experience will be diminished in many areas. Human health will not be significantly affected with project road construction.

Research Needs - As in the case of permanent road construction, there is a need for research in development of minimum road standards for project access.

Road Reconstruction (1.4)

In some cutover forest areas, roads were constructed with no thought to future use. Many are poorly located on the terrain and inadequately constructed and maintained. The roads must be partially or completely reconstructed for forest reentry.

Extensiveness - Road reconstruction is currently estimated to be relatively minor, but expected to increase to moderate levels by 2010. All commercial forests will experience some type of road reconstruction. The USFS is expected to reconstruct approximately 31,000 miles of roads per year. The number of access roads that will be reconstructed or reestablished on better routes in privately-owned forests is not known.

Environmental Factors - Road reconstruction indirectly affects silviculture productivity in that these roads allow access to timber area for harvesting.

Road reconstruction will result in soil loss, but loss should usually be less than that for permanent or project road constructions. However, if reconstruction follows an original road bed that was poorly located for the soil and slope conditions, significant soil loss will occur. Proper relocation of a poorly located road is usually preferable to allowing the original road to remain.

Ecological Effects - Assuming care in layout and construction, road reconstruction will have an adverse, but temporary effect on the aquatic ecosystem. Receiving waters will experience increased turbidity, sediment loading, and a potential reduction in species diversity in highly impacted areas.

Terrestrial effects from road reconstruction will be similar to those resulting from permanent and project roads. However, wildlife disruptions may be less intense since the roads are already present and reconstruction will not involve virgin timber areas.

Aesthetic values may not be particularly affected with road reconstruction. These roads are already present, and, therefore, any displeasing aesthetic impacts occurred with the original construction.

Recreational opportunities will benefit in that access to timber areas is enlarged with road reconstruction. Human health effects are not significant with road reconstruction.

Research Needs - No specific research needs were identified. However, the needs for research involving minimum road standards discussed previously would be applicable to this subtrend.

2. Site Preparation (2)

Site preparation involves practices that treat the soil surface to encourage the desired type of forest regeneration growth. Usually new forest growth is reestablished as soon as possible after harvest in logged areas. Six subtrends are evaluated in this site preparation trend. Each subtrend will have regional importance since each forest type utilizes different preparations for that particular forest growth.

Log Extraction (2.1)

Log extraction methods are used for the establishment or regeneration of a timber species that requires a mineral soil environment for germinating and seedling stages. This method involves dragging logs across the ground, pushing aside the organic overlayer and brush, and baring soil for a seed bed.

Extensiveness - In 1976, extensiveness of use was estimated to be moderate. By 1985 and through 2010, use should decline to limited levels, reflecting the anticipated replacement of natural regeneration with artificial regeneration. All four forest regions have used log extraction methods to some extent, for the regeneration of conifers. However, this site preparation practice seems to be more common in the West after harvest of old growth forests. Site preparation will occur only once in every rotation of 30 to 100 years.

Environmental Factors - With prompt site preparation and regeneration, productivity often increases. Resource use patterns are not expected to change with log extraction practices.

Baring the soil with this practice will result in increased runoff, soil erosion and sediment loadings of receiving waters. The steepness of the terrain, type of soil, climatic conditions, and degree of soil disturbance will determine the severity of erosion and runoff losses. For example, scarifying red pine stands on the flat terrain of Minnesota will result in minimal soil movement, cable yarding on steep Western slopes will result in significant soil loss. However, forest soils would only be subject to these soil disturbances once during each 30 to 100 year rotation and then only until vegetation reappears to protect against soil movement. Currently the trend with log extraction practices is toward better management to minimize soil erosion and runoff losses.

Ecological Effects - The effects of log extraction practices on the aquatic ecosystem will be relatively minor. Since bared soil tends to revegetate quickly, the opportunity for surface transport of materials to water is shortlived. Also, forest areas will only be subject to site preparation every 30 to 100 years. However, log extraction on certain soils and steep terrains could result in large enough sediment loadings so that for a period of time area aquatic life will suffer adverse effects.

Plant and wildlife diversity may decrease in the terrestrial ecosystem. Log extraction practices prevent natural plant succession from reaching climax communities. Wildlife habitat, food supplies, and travel lanes are also destroyed with this practice. With revegetation of the forest area, the emerging ecological community may be quite different from the original community.

Since the principal objective of site preparation with log extraction is to return the forest to production as quickly as possible after harvest, displeasing aesthetic effects will be shortlived. Recreation opportunities will not be significantly affected. Creation of more edge area will temporarily shelter more wildlife for hunting and viewing. Human health effects are not considered to be significant.

Research Needs - Research is needed to determine the minimum amount of site preparation required in establishing regeneration. Also, research is needed to develop more efficient methods and less damaging alternatives to log extraction.

Mechanical Preparation (2.2)

Mechanical preparation involves the use of mechanical equipment having blades, rakes, gouges, chopping wheels, or other implements for vegetation destruction. The forest is reduced to bare ground to favor reproduction of pine primarily in the South.

Extensiveness - The evaluation workshop (Phase I, Volume I) estimated this practice to be in moderate use in 1976, increasing to important use by 1985, and declining back to moderate levels by 2010. In the South, an estimated 29.6 million acres of timber stands, hardwood and pine hardwood, could be cleared and planted to faster growing, more desirable pine. Mechanical site preparation will be used on much of the converted forest stands. However, a large part of these 29.6 million acres is owned by private non-industrial interests who are not necessarily interested in silviculture production from their lands. Thus, the actual acreage of hardwood forests available for pine conversion is not known.

Environmental Factors - Intensive mechanical preparation in the South, for example, is considered to result in the most serious erosion problem that the Southern hill country experiences. The broadcast baring of soils, some of them already depleted from past agricultural use, may foster a dangerous cycle of topsoil and nutrient loss and increased sediment loadings in streams. Compaction and sealing the macrospore structure of forest soils prevents proper water absorption and increases surface runoff. Use of lighter equipment and reducing soil disruptions will tend to reduce the environmental impacts of this practice. However, improvement will be complicated by the fragility of some of the depleted soils now supporting low grade forests.

Ecological Effects - Aquatic ecosystems will experience increases in turbidity related pollution and in thermal pollution to a point where aquatic life may be endangered. Mechanical site preparation results in the conversion of a diverse ecosystem to a monoculture system. Wildlife numbers and diversity are lost with the destruction of habitat, food supplies, and travel lanes. Additionally, the land itself may suffer from losses of topsoil, nutrient cycles, and water holding capacity. Establishment of new vegetative cover will help control erosion, but local-regional terrestrial ecosystems will be permanently changed with conversion to monoculture forests.

Aesthetic values will be adversely affected by this practice. After site preparation, these areas give the impression of agriculture land, with very few residues remaining on the ground. However, where mechanical site preparation has occurred, aesthetics do not seem to be affected to the point of public resistance to this practice. Elimination of diverse forests reduces recreational potential, including hunting and wildlife viewing. For a period following site preparation, quail hunting will improve in some areas until the new forest closes in. Human health will not be affected with this practice.

Research Needs - Research is needed to develop more efficient equipment used in mechanical preparation. Also, research to develop improved alternatives to mechanical preparation is desired.

Burning Prescription (2.3)

Prescribed and controlled burns can be used as site preparation practices on a less intense scale than log extraction or mechanical site preparations. Prescribed burning reduces vegetative competition without the damaging soil disruption effects.

Extensiveness - Annual needs for all prescribed burning total some 12.35 million acres, with 95 percent of these acres located in the South. However, this practice is also used for disposal of logging residues, as well as site preparation. Thus, total acreages of prescribed burns for site preparation alone are not known, but estimated to be of moderate use in 1976. Use is expected to remain fairly constant (moderate) through 1985 to the end of the study period. Future air quality regulations could restrict the use of this practice in the South.

Environmental Factors - Productivity of prescribed burn areas is enhanced by the elimination of overstory and the preparation of seed beds. Certain species, as jack pine, require fire to prepare their cones to drop seeds. Fire also releases nutrients to the soil which can lead to production increases in some areas.

Under controlled conditions, fire should not disturb soil to the extent of causing surface runoff, sediment loadings, or thermal pollution in surface waters. Nutrients released by fire prescription may be leached away if not quickly taken up again. Thus, nitrates in the ground water could temporarily be increased.

Ecological Effects - Ecological effects reflect the use of fire under controlled conditions only. Aquatic effects are very minor from controlled burns. Terrestrial ecosystems will be affected with the reduction of wildlife habitat, food supply, and cover areas. The season of the year and the wildlife species present will determine how severe terrestrial disruptions will be. In general, terrestrial life effects are considered to be less for prescribed burns than for mechanical site preparation and log extraction practices. Additionally, the nutrient cycle is temporarily accelerated, but should return to its norm without significant effects on the soil.

Aesthetics will be affected, but should recover within a relatively short time. Recreational opportunities are increased to the extent that clearance of underbrush provides for easier access to wildlife in hunting. Human health will not be affected with current and projected use of prescribed burns. Burning vegetation does not release toxic substances or noxious fumes to the air. The amount of particulate matter from controlled burnings is also relatively low.

Research Needs - There is a need for research in determining the time required for soil biota to recover from prescribed and controlled burning. Since the recovery time will vary considerably between regions, study is required to identify these regional differences. Further, more research is needed to determine the optimal time (seasonally) to burn in order to minimize the ecological impacts.

Chemical Treatment (2.4)

Chemical treatment for site preparation involves the application of herbicides to remove hardwood trees and/or brush weed species and to provide for replacement with more desirable species, often softwood. Herbicide applications may be followed by fire to remove dried vegetation. With brush removal only, fire is often not needed, and natural revegetation will replace the cover removed.

Extensiveness - In 1976, the use of herbicides for site preparation was minor. By 2010, this practice is expected to increase slightly to limited levels. When herbicides are used, application rates are comparable to those used in agriculture, but application is once in a 30 to 100 year rotation. It is estimated that about 99 million acres may be treated with herbicides over time.

Environmental Factors - Herbicide use for site preparation will enhance productivity and has certain advantages over site preparation methods that disrupt the soil surface. Soil loss will be much less for this practice and may be insignificant in most areas. Water flow will be tempoarily increased until revegetation occurs.

Herbicide levels in receiving waters may be increased with surface runoff and aerial drift during application. While herbicide application in a given area will usually occur, only once during a 30 to 100 year rotation and have minimal impacts over time, careless application (directly spraying over water or aerial application on a windy day) could potentially result in significant pollution levels in water. Streamside buffer zones and careful application methods are expected to minimize herbicides entering surface waters, however.

Ecological Effects - With careful application, herbicide use for site preparation is not expected to have significant aquatic effects. Terrestrial ecosystems are affected adversely with herbicide use. All vegetation is removed, thus destroying wildlife habitat, food supplies, and cover plus reducing species diversity. Plant and animal successions may be abruptly changed with this practice.

Clearance of underbrush will make for easier access for certain recreational opportunities, e.g., improved hunting, easier hiking. Aesthetic impacts will be adverse with the destruction of vegetation. Human health effects will be insignificant with careful application. Potential human health dangers do exist with direct contact with certain herbicides during application.

Research Needs - Further research is needed in identifying the effects of herbicide in the environment as a result of chemical treatment. This research is expected to bring into focus the reaction of the soil biomass to chemicals and the impacts of volatization of chemicals in the atmosphere.

Fertilizer Treatment (2.5)

Fertilizer treatment is required for site preparation in forest areas that require nutrient supplement for successful establishment of desired species.

Extensiveness - Fertilizer treatment of forest land is used primarily in the South, where moist, phosphate deficient soils need nutrient supplement for the growth of loblolly pine. Currently the use of fertilizer in all forest areas is minor, however. By 1985 and through 2010, use is expected to increase only to limited levels. The expected increase in the South's use of fertilizer will occur with the increased conversion of poorly drained lands (wetland areas) to forest areas. Some 2.0 million acres of land will have been drained by 1977 with many areas requiring phosphate supplements of 50-100 lb/acre.

Environmental Factors - Productivity of an area will be increased with fertilizer application, especially when drainage plus phosphate addition creates a pine forest out of an area previously unable to support forest growth. Fertilizer use will be increased from a zero base to high levels of application. Phosphate requirements are expected to be 50-100 lb/acre and phosphate levels in nearby surface water may increase with fertilizer treatment. However, no other pollutant changes will result.

Ecological Effects - The ecological effects assessment reflects only the use of fertilizer treatment for site preparation (ecological effects of land drainage are presented below in the soil moisture control subtrend). High levels of phosphate application could potentially cause eutrophication in the aquatic ecosystem. Species diversity and water quality will be adversely affected in aquatic systems. Terrestrial effects (from fertilizer application alone) will not be significant. Human health effects are not expected to result from fertilizer application, although phosphate loads may affect the potability of water.

Research Needs - Research is needed to determine the environmental effects of phosphate applied to forest lands, primarily in relation to the aquatic system. The effects of other nutrients, if applicable, should also be assessed.

Soil Moisture Control (2.6)

Soil moisture control refers herein to the drainage of wetlands in the South for the successful establishment of desired forest species, usually loblolly pine.

Extensiveness - Extensiveness of soil moisture control is expected to be limited and remain fairly stable between 1976 and 1985. By 2010, use should decline to minor levels. The total amount of wetland available for conversion is not known, but is probably not less than 5 million acres.

Environmental Factors - Silviculture productivity will increase with the drainage of wetlands and the establishment of loblolly pine forests. Fertilizer use is expected to increase from a zero base to relatively high application rates, e.g., 50-100 lb/acre of phosphates.

Drainage will result in water movement from stagnant areas, but the movement is expected to be too slow to result in significant sediment transport. Surface water may become charged with phosphates, but the levels have not been determined.

Ecological Effects - Soil moisture control is expected to have major aquatic and terrestrial effects. Drainage of wet lands will affect water table levels. This practice may result in a complete change from an aquatic ecosystem to a terrestrial ecosystem. Many wetlands provide habitat that is critical for the existence of wildlife species, especially waterfowl using wetlands for wintering areas. Plant species and the ecological community existing in the moist environment will be replaced with the limited diversity of pine forests.

Recreational opportunities for waterfowl hunting and wildlife viewing will be diminished with drainage of wetlands. Aesthetics will be adversely affected since drainage of wetlands represents an irreversible change in the type of visual experience available to man. Human health is not expected to be affected by actual drainage of wetlands except that insect populations may be reduced in stagnant areas.

Research Needs - There is a need for research involving the long term effects of extensive drainage and phosphate loadings associated with site preparation in the wetlands of the Southeast. Ecosystem changes may be irreversible and long-term species diversity effects should be assessed.

3. Log Extraction (3)

Log extraction is the process employed to bring useable portions of a tree to the point of loading for transport. Methods and equipment used in log extraction vary with regional difference in timber size, species harvested, terrain, and other physical aspects. Closely tied to log extraction is the cutting system (5) trend which considers the extent and type of timber to be removed. Log extraction methods and equipment will largely be determined by the type of cutting system.

Harvest Unit Layout-Intensity of Effort (3.1)

This practice is particularly important in the harvest of old growth forests in the West where silviculture methods generally favor conversion from uneven aged old growth to even aged regeneration. Planning has always been an important phase of extraction, but generally oriented toward the lowest cost. This practice has increased the intensity of effort to balance cost savings against environmental cost. Planning trends are toward better control of size and shape of harvest units, proper location of cutting units, use of vegetation to hide cuts from conspicuous view, and mixing of clearcut and selective cut systems to achieve minimal environmental impacts.

Extensiveness - Planning of harvest unit layouts is expected to become increasingly important in old growth forests of the West. Extensiveness was estimated to be moderate in 1976, and will be important in 1985 and 2010. Since much of the remaining old growth forests are in federal ownership, institutional authority exists to achieve controlled planning of harvesting.

Environmental Factors - Productivity is not likely to be significantly changed with careful harvest planning. Timber may be removed from a given cutting block at a slower rate with planning and thus, decreases productivity somewhat. However, planning may also increase log utilization and increase productivity.

Surface runoff and soil loss will be reduced with careful harvest planning, but losses may still be significant in some areas. Streamside buffer zones may also be used in the harvesting to reduce sediment transport, although such management zones are primarily used to provide stream shade and protect the water temperature. Nutrient levels will increase in the soil with timber residues remaining, and these nutrients are potentially available for leaching.

Ecological Effects - Harvesting will result in adverse ecological effects, but the effects are expected to be less intense with better harvesting plans. Soil losses will be reduced but receiving waters will still experience increased sediment and turbidity. These effects will occur but once during each harvesting period, and then only until revegetation appears. Wildlife habitat will still be destroyed, but intensive harvest planning will reduce the adverse impacts. The ecological community will be less diverse and less stable in even-aged forests compared to old growth forests.

Recreational opportunities are expected to decrease with this practice. Adverse aesthetic effects will be minimized with careful planning, but harvesting is still expected to result in some displeasing visual views. Human health will not be significantly affected by this subtrend.

Research Needs - Long-term environmental impacts resulting from trends in harvest unit layout-intensity of effort need to be determined.

Equipment Use and Development (3.2)

Until recently, log extraction methods used machinery adapted from other uses. Now the trend is toward machinery designed specifically for timber harvesting needs with consideration for timber size, species harvested, and terrain. Fewer innovative changes will be made with machinery for harvest of old growth forests in the West. In the South, however, equipment is being developed to thin young stand and to harvest pulpwood and smaller saw timber. Older manual operations will give way to fully mechanized methods.

Extensiveness - The increase in roundwood production projected to 2010 will increase the need for far more equipment, especially in the North and South, possibly double what was in use in 1976. In the West, equipment needs are expected to remain fairly stable, since production will decline slightly here. Extensiveness of equipment use and development is moderate in 1976 and expected to increase to major levels by 2010.

Environmental Factors - Productivity is expected to increase significantly with new equipment developments. Tree pulling equipment can recover 20 to 25 percent of the tree volume that otherwise stays in the ground. Soil compaction is less with newer equipment designs, so regeneration of a cut area will be enhanced.

Many of the new equipment designs are effective in reducing soil disruptions and consequent soil loss and water damages on steep and fragile slopes. However, it should be emphasized that equipment changes will reduce, but not prevent problems of surface runoff, sediment losses, and water quality degradation.

Ecological Effects - Development of new equipment and its use will reduce the adverse ecological effects of harvesting. Sediment and resulting turbidity will be reduced in the aquatic systems. Soil compaction and erosion will be reduced and benefit the terrestrial ecosystems.

Recreational opportunities and aesthetics will not be significantly affected by this subtrend. Human health is not a factor with equipment use and development.

Research Needs - Research to design new equipment to meet the specific needs of each of the regions is needed. Logging equipment needs to be developed which will decrease soil disturbance, detachment and transport. Research efforts should be focused on the requirements in the North and South because of the significant increases in production expected.

4. Utilization (4)

Silviculture productivity can be increased by utilizing the total forest biomass. More fiber is harvested per unit of area through extraction residue recovery, minimum size and quality extension, and species use enlargement practices.

Extraction Residue Recovery (4.1)

With extraction residue recover, greater use is made of the total fiber in each harvested tree. While only large sound logs used to be merchantible in the past, smaller logs and logs with defects are now being marketed.

Extensiveness - About one half of the nation's logging residues are generated in Pacific Coast forests, 22 million tons of logging residues each year. Logging residues will vary with forest ownership and type of sales method. On industrial owned forest land, average residue volume is 1,330 ft^3/acre. On national forest land, average residue volume is 3,130 ft^3/acre. The primary reason for greater utilization on private industrial owned land is the type of sales program. Lump sum sales programs, compared to the NFS scaled volume sales program, results in greater utilization of logging residues.

Between 1968 and 1972, recovery of utility logs more than doubled, increasing from 177 million ft^3 to 480 million ft^3. During the same period, roundwood chip production increased from 75.5 thousand tons to 2049 thousand tons.

Even with the increased use of logging residues in the past ten years, the potential exists for further increased residue recovery. At the national level, 80 percent of pulp mill requirements are supplied by roundwood, and only 20 percent by residues. In the fuel using sector of industry in the Pacific Northwest, 15 percent of fuel requirements are from mill residues, the remaining 85 percent comes from fossil fuels.

Currently, it is not economically feasible to transport and market some forest residues at existing process locations on the Pacific Coast area. In the NFS, residue material is being yarded to concentration points (YUM program) where it is decked for future use or for burning.

The evaluation workshop (Phase I, Volume I) estimated extraction residue recovery to have moderate levels of use in 1976 and 1985. By 2010, use will decline to minor levels, primarily due to more efficient harvesting techniques and the replacement of old growth forests with young even-age timber in the West.

Environmental Factors - Recovery of marketable forest residues will increase total annual silviculture production. Other forest residues are not marketable and are collected for burning purposes only.

The environmental impacts of increasing utilization of the forest biomass will be beneficial up to a point. Partial removal of forest residues reduces fire hazards, provides barriers against surface runoff and soil loss, and provides protection for the regenerating forest. Additionally, partial removal of residues will reduce the need for controlled burns that might otherwise be used. Removing all residues from a harvest sight, however, will increase the potential for surface runoff, soil loss and nutrient loss.

Ecological Effects - Moderate levels of utilization are expected to have beneficial aquatic effects. In the aquatic ecosystem, less debris will enter streams, resulting in improved aquatic habitat. In the terrestrial ecosystem, wildlife habitat and species diversity do not specifically depend upon the presence or absence of logging residues, except for certain cavity dwelling species. The USFS now observes a policy of leaving a certain number of dead trees standing for these animals. Complete residue removal would eliminate edge area and, consequently, reduce species numbers and diversity.

In the West, aesthetics will be enhanced by partial removal of logging residues. Logged sites will have a more orderly appearance. Total utilization would further enhance aesthetic values, but provides for the possibility of other environmental injury.

Complete utilization is expected to have a minor effect on recreational opportunities, by allowing for easier travel through cutover areas. Human health will not be significantly affected with residue recovery practices.

Research Needs - With an expected increase in the extraction residue recovery, research needs have been identified involving both the extent of utilization and the expected environmental effects. Consequently, future research should address the level of utilization of biomass considered optimal and evaluate the ecological effects of alternatives in level of utilization.

Minimum Size and Quality Extension (4.2)

Increased utilization of forest fiber can also be accomplished by using the smaller trees removed during thinning practices for stocking control, using smaller top diameters, and using the whole tree, including roots.

Extensiveness - Use of minimum size and quality extension practices is especially applicable to the South's pine forest and to a lesser degree, in the North's forest systems. In the West, use is less significant because emphasis is primarily on old growth liquidations. Industry that depends strongly on roundwood fiber favors the utilization of smaller materials. Extensiveness of this practice, minimum size and quality extension, was estimated to be moderate in 1976 and expected to increase to important levels by 1985 and major levels by 2010.

Environmental Factors - In terms of wood fiber, silviculture productivity increases significantly with minimum size and quality extension utilization. Not all forest species can be managed for minimum size, but at least one third of all southern pine may be managed for this.

Removal of the entire tree biomass results in complete soil baring and increased soil disturbances. Significant soil erosion losses and sediment loading of receiving waters are expected in some forest areas, especially in the hilly country of the South. Nutrients will be irretrievably lost in the nutrient cycle with whole tree utilization. Some soils will require replacement of nitrogen, phosphorus, and potassium before successful regeneration can occur.

Ecological Effect - Complete utilization will have adverse aquatic and terrestrial effects. Turbidity increases and the potential for thermal pollution also increases. Terrestrial systems will have decreased diversity in both vegetation and wildlife species. Soil nutrient cycles may be severely disrupted in some areas due to extensive material removal. Aquatic and terrestrial effects will be limited to those regions using this practice, primarily the South.

Aesthetics are not expected to play an important role with this practice because this practice is important specifically, in the South where little forest land is held in public ownership. Recreation potential will be decreased since there will be minimal natural cover on the land. This practice is not expected to have significant human health effects.

Research Needs - Needs have been identified for research designed to determine kinds, volumes, and sizes of material to be left on site to aid in decreasing the pollution effects of extraction.

Species Use Enlargement (4.3)

Forest utilization is expanded under this practice to include tree species once considered non-commercial, specifically hardwood species. Technological developments have largely been responsible for the use of a broader range of species.

Extensiveness - Species use enlargement will be most applicable in the North and South forest regions, where many hardwood species exist. Application in the West will be limited since much of that forest land is in desirable softwoods.

By 2010, the U.S. will be consuming an estimated 12.2 billion ft^3 of pulp wood compared to 4.4 billion ft^3 in 1970. Hardwoods will supply 37 percent of this volume, an increase from 28 percent in 1970. To achieve this production level by 2010, it will be necessary not only to increase harvest of desirable species, but also to use a broader range of species for harvest. Since hardwood species tend to be small, poor in form and do not have the desired seasoning characteristics or dimensional stability, their use for lumber and plywood is not expected to greatly increase.

Environmental Factors - Annual silviculture productivity will increase significantly with the harvest of a broader range of tree species. Additionally, marketing of species that might otherwise be disposed of by mechanical or chemical means tends to reduce cost for stand improvement and forest conversion.

The type of harvest and logging methods used will determine the extent of soil disturbance and consequent soil loss. As with other utilization practices, total removal of all forest fiber bares the soil and increases the potential for surface runoff and soil losses. Soil nutrient cycles will also be disrupted with whole tree utilization. Other harvesting practices will allow residues to remain, and the resulting soil loss is expected to be less than for complete utilization.

Ecological Effects - Ecological effects of species use enlargement will largely depend upon the harvest and logging practices used. Aquatic ecosystems may experience increased turbidity and possible thermal pollution with intense utilization of forest fiber. Complete tree removal including roots results in loss of water retention capacities by the soil. Less intense harvest and utilization practices will cause less soil disturbance and reduce the potential for adverse aquatic effects.

The terrestrial ecosystem may experience loss of wildlife habitat and decreased species diversity with the elimination or reduction of a tree species. Recreational opportunities will be adversely affected if complete utilization of all tree species becomes a common practice. Aesthetic values are expected to also be adversely affected with this practice due to reductions in wooded vegetation. Human health is not expected to be affected.

Research Needs - As discussed above, there is a need to determine the pollution effects of alternative levels of utilization and ecological effects.

5. Cutting System (5)

Cutting systems employ two basic management practices for forest harvest: even-aged management and uneven-aged management. Even-aged cutting practices are clearcutting, shelterwood cutting and seed tree cutting. These three cutting systems allow for the removal of mature tree stands and the establishment of new stands, all of a single age class. Single tree and group cutting are uneven-age management practices. This type of management produces stands in which trees of various ages are intermingled.

While the cutting system trend was ranked ninth (out of 10 silviculture trends) for environmental implications by the Phase I evaluation workshop, one subtrend, clearcutting, has become a sensitive and controversial issue with the public. Thus, clearcutting has been included for detailed analysis in this Phase II study. Other cutting system subtrends are excluded from this assessment.

Clearcutting (5.1)

Clearcutting is an even-aged forest reproduction practice in which all trees are removed in the harvest area. This area may then be regenerated by residual reproduction or by natural or artificial methods after cutting.

Extensiveness - Actual extensiveness of clearcutting in 1976 is not known, but estimated to be at important levels. In the Douglas fir region, 39,500 acres of old forest growth is harvested by clearcutting. In the South, clearcutting is expected to increase as a result of shortened rotation periods, 15 years for some species. By 2010, extensiveness of clearcutting is expected to reach major levels. However, use of clearcutting may be restricted on some federal forest lands, and shelterwood cutting substituted as an even-age management practice.

Reducing clearcut area size and engineering the cut to conform to topographic features and to be less visible from principal viewing points are expected to be future management practices with clearcutting.

Environmental Factors - Clearcutting practices demonstrates high potential for maximizing fiber yield in a number of forest types, and provides the best opportunity for establishment of new stands.

Clearcuts have been responsible for large pollutant loadings in the environment. The potential still exists for significant adverse impacts, but precautionary measures can reduce these impacts. However, soil loss will still occur with large bared soil areas. On fragile soils and on steep terrain, indiscriminate use of clearcutting can cause mass wasting.

Clearcutting can be used to control water yield in the Rocky Mountains with properly engineered path cuts that trap winter snows. This will cause increased spring runoffs. Water yields are temporarily increased between the time an area is cut and before vegetation is reestablished to take up moisture.

Water temperature increases have also occurred with clearcuts. More current practices with clearcutting, leave the streams shaded to maintain temperature stability.

Ecological Effects - Aquatic ecosystem may be adversely affected with increased turbidity and thermal pollution. With use of buffer zones and careful management, adverse aquatic effects will decrease in intensity and may be relatively insignificant in some cut areas.

With clearcuts, wildlife habitat, food supplies and travel lanes are disrupted. Wildlife species that inhabited the uncut forest will be displaced; and, with revegetation, a wider diversity of ground and bush-dwelling species will appear. Deer populations are expected to increase significantly in some forest cut areas.

Recreational opportunities are adversely affected immediately following clearcutting. After revegetation, hunting, wildlife viewing, and berry picking are enhanced.

Aesthetics are also adversely affected with clearcutting and subsequent logging practices. Removal of harvest residues, careful clearcut site planning, and other management are expected to reduce aesthetic effects to some extent. Human health is not expected to be significantly affected with this practice.

Research Needs - As indicated above, major disruptions can be expected in the terrestrial systems. Because of this, research is required not only on the short term effects but also on the long term effects of clearcutting.

SECTION III

RESEARCH NEEDS

Throughout this study many types of data and information were identified and sought through secondary sources in order to complete the desired environmental assessments. As was expected, the desired research data were often meager and seldom adequate to quantitatively analyze the environmental effects of a given trend or management practice in either agriculture or silviculture. Consequently, and as incorporated in the study's plan of work, qualitative value judgments of agricultural, silvicultural, and environmental professionals were obtained and utilized. Future studies involving the environmental implications of agricultural-silvicultural activities can be expected to face similar data and information constraints.

As a guide to further data base development involving environmental research, this section outlines the most pressing needs that were identifiable throughout this study. It should be recognized that many on-going public and private research programs will contribute to these needs; however, the diverse conditions that exist throughout agriculture and silviculture are such that site specific experiments are difficult or impossible to generalize about. Caution must be exercised, therefore, in assuming that research conducted in limited geographic areas will necessarily yield data on environmental effects valid for other areas and conditions.

Agricultural and silvicultural environmentally-related research needs, as viewed from the perspective of EPA's overall responsibility, might be categorized into four research areas as follows:

1. Production Efficiency Research
2. Pollution Measurement Research
3. Pollution Reduction Research
4. Ecological Impact Research

Production efficiency research would develop or assess the technology utilized to improve production yields and efficiency, including pollution-related impacts. Pollution measurement would determine the actual types and quantities of pollution generated in various production processes. Pollution reduction research would develop or assess alternative methods to reduce the generation of pollution. And, ecological impact research would quantify ecological and other environmental impacts. (A fifth area, extensiveness research, would determine the extent to which pollutant-generating resources, production practices, or developments are being utilized, but such research is generally considered outside of EPA's primary responsibility.)

The following discussion of specific research needs is presented first for the agriculture sector and then for the silviculture sector. Also, within each sector, the research needs are identified according to the four research categories as defined above. These needs reflect the broad range of research that will be required to comprehensively assess the environmental implications of trends in agriculture and silviculture. However, other and more specific research needs can be readily perceived within the framework shown; thus, the research needs presented are intended principally as a guide in research planning. Various institutions, not just EPA, have either an explicit or an implicit responsibility to foster research in the various designated categories.

Importantly, one should note that the research need categories are not mutually exclusive. Such matters as research into the environmental effects of varying tillage practices will, for instance, also involve research into their differing nutrient and pesticide requirements and their consequent environmental effects. When one recognizes the interrelationships that exist among all the agricultural subsector trend practices and their environmental effects, one recognizes, also, the conceptual impossibility of definitively ranking on the basis of need, all of the research possibilities identified in this study. Finally, the listing of research needs is not exhaustive. The study sought to identify those that offer promise; thus, in some instances, research needs were not identified in all need categories for all trend practices.

A. Agriculture Sector Research Needs

Based on this study's findings, the most needed environmentally-related research topics in agriculture are as summarized in Exhibit III-1 below. These research needs are categorized by subsector/trend (see Exhibit rows) within agriculture and by the research categories (see Exhibit columns) as were defined above.

The following discussion incorporates not only the trends as have been assessed in this Phase II document, but also selected additional trends from the Phase I (Volume I) analysis for which comparable research needs exist.

Production Efficiency Research Needs

Improved production efficiency is an indirect means of achieving environmental quality production and enhancement. That is, technological and other developments that increase agricultural production efficiency have often required lower rates of resource use, e.g., land or fertilizer, in order to meet specified yield goals. Hence, the environmental effects are favorable, especially in relative terms in the U.S., where substantially more pollutants would have been generated if production efficiency improvements had not been realized. Such, for instance, is a frequent effect of the work of the U. S. Department of Agriculture. The Department, as is

Exhibit III-1. Summary of agriculture sector research needs by trend and research category

Page 1

Agriculture Subsector/Trend	Production Efficiency Research Needs	Pollution Measurement Research Needs	Pollution Reduction Research Needs	Ecological Impact Research Needs
CROP PRODUCTION SUBSECTOR				
Soil and Water Management (Runoff and Erosion Control)	Develop more efficient farm implements. Determine optimum use of fertilizers and pesticides with narrow rows. Develop alternatives to the use of toxic pesticides, e.g., paraquat.	Determine losses from control measures under varying conditions; e.g., soil and application rates.	Determine effectiveness of contouring and other soil erosion measures. Investigate the feasibility of producing additional crops in narrow rows.	Determine the effects of pesticides on human health. Determine the optimum maintenance management of terraces and grass waterways for wildlife habitat.
(Conservation Tillage)	Determine optimum fertilizer and pesticide use under no-till and reduced till practices. Determine the optimum amount of residue to be left on the soil under conservation tillage.	Determine pesticide losses under reduced tillage.	Determine effectiveness of alternative reduced tillage methods in reducing pollutant losses, e.g., nutrients, pesticides, sediment.	Determine ecological effects of increased pesticide use under conservation tillage.
(Wind Erosion Control)		Determine wind erosion losses under strip-cropping barrier rows and free wind breaks.	Develop more efficient systemsin wind erosion control.	
(Improved Water Application)	Determine the feasibility of diverting return flows for other productive uses, e.g., wildlife preserves. Investigate the use of effluents in sprinkler irrigation. Improve irrigation systems and scheduling.	Determine quality of return flows under varying conditions.	Determine the feasibility of water renovation through filtering and desalting. Determine practicable alternatives for treatment and disposal of tail water.	Determine effects of salinity on human health and animal populations. Determine effects of irrigation practices on ground water depletion.
(Improved Seeds and Plants)	Develop more resistant seeds and plants to include weather, salt, insect, and neamtode. Develop seeds and plants to increase crop yields.		Develop seeds and plants resistant to pests requiring chemical treatment.	Include environmental assessments as a part of research undertaken in seeds and plants improvement.
(Using Soil-Plant Analysis)	Develop more efficient techniques in soil plant analysis to enhance productivity.			Evaluate ecological effects associated with the use of soil-plant analysis.

Continued . . .

Exhibit III-1 (Continued)

Agriculture Subsector/Trend	Production Efficiency Research Needs	Pollution Measurement Research Needs	Pollution Reduction Research Needs	Ecological Impact Research Needs
CROP PRODUCTION SUB-SECTOR (Con'd)				
Nutrient Management (Methods of Nutrient Application)	Develop more effective methods of nutrient application.	Compare rutrient losses under varying methods of application.		Determine environmental implication of developments in application techniques as they are developed. Determine long term effects of leaching of other ions with nitrogen and movement of ions down into the soil profile. Determine regional implications of fall application.
(Development of Improved Fertilizers)	Develop more efficient fertilizers.		Develop fertilizers designed to reduce pollution effect, e.g., micro-encapsulation.	
(Development of Nitrogen-Fixation Sources)	Develop sources, both legumes and non-legumes, for biological nitrogen-fixation.	Determine extent of nitrate leaching from nitrogen-fixation sources.		
Pesticide Management (Pesticide Application Methods)	Develop more efficient means of pesticide application including aerial application and dual application of fertilizers and pesticides.	Determine extent of pesticide loss in aerial application.	Develop means of reducing drift in aerial application.	Assess differences in ecological effects of alternative methods of pesticide application.
(Development of New Biological and Chemical Pesticides)	Develop more effective chemical and biological pesticides. Develop the effective use of pred.tors and parasites for biological pest control.		Develop biodegradable pesticides.	Determine ecological effects of newly developed pesticides, including effects of agents on non-target organisms and their effects after the prey has been eradicated.
(Scouting and Integrated Controls)	Develop more effective integrated control systems. Develop effective surface and remote sensing scouting programs to enhance production.		Develop integrated control systems designed to reduce chemical use.	Include ecological assessments as part of ongoing research involving integrated system.

Continued . . .

Exhibit III-1 (Continued)

Agriculture Subsector/Trend	Production Efficiency Research Needs	Pollution Measurement Research Needs	Pollution Reduction Research Needs	Ecological Impact Research Needs
FEEDLOT PRODUCTION SUBSECTOR				
Residual Disposal Management	Determine economic feasibility of utilizing feedlot waste in crop production. Assess the efficiency and feasibility of recycling wastes in feeding rations.	Determine nutrient losses resulting from application of manure at disposal rates.	Evaluate ration rotation as a means of reducing the potential build-up of copper, arsenic, and sodium derived from feed rations.	Determine effects of high sodium content in rations on soil deflocuclation. Determine long term effects of nitrates and other nutrients in groundwater.
Improving Feed Efficiency	Develop means of enhancing the nutritive value of roughage and other fiber content of feed. Develop more effective means of utilizing nonconventional feedstuff and animal wastes in feeding.	Determine nutrient losses from newly developed feed rations.		
RANGE AND PASTURE MANAGEMENT SUBSECTOR				
Grazing Management	Develop more effective grazing systems utilizing innovations such as complementary forage seedings.	Determine nutrient and sediment losses under the various specialized systems.		Determine ecological effects of complementary forage seedings.
Increase Forage Quality and Quantity	Develop means of increasing the quality and quantity of forage.			Determine ecological effects of introducing new species into ranges.
Range and Pasture Renovation	Develop more efficient renovation systems.	Determine pollution effects of newly developed renovation systems.		Determine long term ecological effects of the various renovation systems(chemical, mechanical, and prescribed burning).

generally recognized, is a principal source of production efficiency improvements for agriculture, and a consequence of those improvements is often improved environmental effects. Too, agribusiness conducts much independent research and, consequently, fosters environmental beneficial production efficiency improvements.

Even though production efficiency improvements generally have only indirect environmental implications and may not, therefore, be of primary concern to EPA, the future environment of the nation will be strongly influenced by such improvements. As a minimum within a comprehensive research framework, the monitoring of emerging and prospective production efficiency improvements is a vital research task.

Crop Production - Soil and Water Management. As is first shown under the production efficiency research needs column in Exhibit III-1, several research topics are classified primarily as soil and water management related. For example, the use of narrow rows, an increasing trend practice, is believed beneficial in stabilizing the soil, and, in many cases, this practice improves production efficiency per unit of land cultivated without corresponding increases in fertilizer use. Thus, either the same output may be produced with less environmental pollution, or more likely, greater output can be obtained without a significant change in associated environmental effects. The production efficiency aspects of the subtrend need to be more fully assessed. More specific research is required in the determination of the optimal rates of application of pesticides and fertilizers. Also, the adaptibility of narrow rows in the production of crops other than corn and soybeans needs to be more fully investigated.

Within the crop production subsector, improved water applications result in production efficiencies which should be fostered not only because of efficiency gains, but because of their favorable environmental implications. Improved methods of water application, improved scheduling procedures, and the use of new sources of water, e.g., waste water effluent, are specific areas needing research.

In the past, much research has been focused on the development of higher yielding crop seeds and plants. While this research should be continued, increased genetic research is also warranted to improve the resistance of plants to factors such as weather, insects and diseases. Such developments will potentially reduce future potential pesticide pollution problems.

Crop Production - Nutrient Management. Further research related to nutrient management will likely result in production efficiency improvements and an aggregate beneficial environmental effect. In particular, developments can be expected involving the form in which fertilizer is applied, the timing and frequency of application, and the type of applications used. In the past, fertilizer technology has contributed significantly to the increasing crop yields experienced in U.S. agriculture. The rising costs in fertilizer production have brought into focus the necessity for continued research in this area. Specifically, research needs to be undertaken to develop more efficient means of application and more effective forms, such as microencapsulation. Closely related to the needs involving timing and frequency of application is the need for the development of more effective means of conducting soil-plant analysis. Only a minor portion of the total crop acreage is currently covered by soil-plant analysis. Improved techniques, plus a greater emphasis on implementation of such techniques by the research and agribusiness community, would stimulate the needed expansion in the acreage covered.

Crop Production - Pesticide Management. Pest management technology has been one of the major determinants of the high productivity of U.S. agriculture with toxic chemicals providing the basis for contemporary practices. Public concern about these chemicals has led to more stringent regulations and, in some cases, a prohibition of specific chemicals. These restrictions have resulted in a greater reliance on certain compounds and, also, the substitution of less effective alternatives. Consequently, the need for additional research is readily apparent. The breadth of recent and ongoing research is reflected in the subtrends reviewed in this study. Emerging chemical developments include microencapsulated systems, surfactants and biodegradable pesticides. In the biological field, the subtrends covered developments in juvenile hormones, pheromones, sterile males, and predators. Although considerable progress has been made in such research, most of these remain largely in the experimental stage with recognized research requirements. The use of predators and parasites in biological pest control shows a great deal of promise; however, additional research is needed before these controls can be used on a large scale. Research is needed to identify and develop other biological and chemical agents which will provide more effective control of pests. Furthermore, increased research is needed to develop integrated pest management controls, i.e., chemical, biological and mechanical combinations to meet specific pest problems.

Too frequently pesticides have been applied as a matter of prevention of potential threats, thus contributing to a high level of use. More efficient use depends on identification of real threats. Consequently, research needs to be accelerated in the area of sensing in order to develop effective surface and remote-sensing scouting programs for the detection of pest problems.

Pest management research is needed in conjunction with other crop management trends, namely, trends in reduced till and no-till practices which are expected to be utilized substantially more in the future. Because of improved water conservation and reduced runoff and erosion, increased production efficiency has occurred. On the negative side, however, greater weed and insect problems generally occur; thus, greater chemical pesticide use and its consequent potential pesticide residue problems are common. This particular trend should be monitored for its production efficiency implications, and it should be more carefully researched in terms of its direct pesticide use implications.

Feedlot Production. Production efficiency improvements in livestock feeding have both direct and indirect environmental benefits. First, on a per pound of gain basis, less direct wastes are generated, i.e., a higher percentage of the feeding ration is converted to useable end products. Second, because less grain and roughage are needed to finish feedlot livestock to a specified grade, less feed need be produced to obtain a given total yield; thus, an indirect and favorable relative environmental effect will result. Over time, feeding efficiency improvements, e.g., in the order of 15 to 20% per pound of gain, could have a significantly large macro-level effect on the nation's environment. Hence, additional research to further enhance feeding efficiency improvements is warranted.

Pollution Measurement Research Needs

An initial step in the assessment of the environmental implications of agricultural trends was the identification of major pollutants generated by various practices and developments. As pointed out above, the research data required for an effective quantitative analysis was, in most cases, inadequate. Although extensive research has been done in the identification and measurement of pollution from non-point sources, it has generally been oriented towards specific pollutants under controlled run-off conditions. Thus, because the pollution effects caused by specific practices have not been documented to the extent that realistic future projections of effects can be made, the environmental impacts of expected changes in practices cannot be accurately determined on a quantitative basis.

However, models have been and are being developed with the objective of simulating pollution levels in water basins under varying production-related conditions. Most often, such models seek to estimate pollutant load changes into streams as a function of management practices. Also, some models seek to estimate instream water quality conditions given alternative management practices. These models have usually been inadequately developed to complete either regional or national assessments, and further pollution measurement research of this type is needed to obtain useful estimates of the levels of non-point sources of pollution. Additionally, the simulation models should be developed to incorporate and, yet, distinguish each of the subsectors of agriculture so that the relative environmental significance of each can be more accurately determined and assessed.

Crop Production - Soil and Water Management. Trends in soil and water management practices indicate that significant environmental effects will likely occur. For example, substantial increases in no-till and reduced-till culture practices are expected. Such practices, predicted to reduce runoff will, also, increase pesticide use to control weeds, insects and diseases. Improved pollution measurement research is, then, needed to determine the nutrient and chemical losses for alternative tillage practices and soil conditions. The net environmental effects of reduced-tillage practices were judged to be beneficial by this study's workshop, yet improved pollution measurement is needed to verify this judgement.

Within major irrigated crop production regions, a major and growing problem is the increasing salinity of irrigation return flows. Better measurements of the existing pollution effects of these return flows are needed, and, perhaps more critically, the future environmental effects of high salinity return flows should be predicted as a guide to the severity of their future potential effects.

Crop Production - Nutrient Management. In nutrient management, numerous developments in application methods and fertilizer formulations have occurred in the past and are expected to continue in the future. Measurement techniques need to be designed to measure the nutrient losses expected from each of these developments. This would facilitate the identification of feasible alternatives for use in pollution control.

Range and Pasture Management and Feedlot Production. Numerous studies have been conducted regarding pollution associated with the range and pasture management and the feedlot production subsectors. However, there is an inadequate quantitative basis on which estimates of this pollution can be made for the various practices and variety of conditions. Consequently, the need for improved pollution measurement is apparent in these two subsectors.

Pollution Reduction Research Needs

A major step in this study's assessment of trends was its identification of current and potential practices which impinge upon environmental concerns. One of the objectives of this step was to assist EPA in its efforts to identify feasible technologies for the prevention and control of adverse environmental effects. In this study, many of the trends assessed were found to have both a pollution reduction effect and an improved production efficiency effect (i.e., runoff and erosion control practices, conservation tillage, and improved nutrient application). Continued research to develop similar dual-benefit practices is desired. In the future, however, stringent pollution reduction practices may be required without associated production efficiency benefits. Such practices, although not among the leading trends assessed, should be realistically included in research programs.

Crop Production - Soil and Water Management. Soil management practices such as contouring, narrow-row cropping, and reduced-till or no-till cultural practices for varied crops should be researched to indicate their potential and relative levels of nutrient, chemical, and sediment run-off and subsequent environmental effects. Research needs are important, also, in water management. Practicable alternatives for the treatment and disposal of irrigation return-flow, water need to be identified. With the increasingly apparent potential for the depletion of ground water in the West, research is needed to measure the impact of irrigation on depletion levels and to assess the beneficial effects on water renovation of filtering and desalting techniques.

Crop Production - Nutrient Management. Of principal consideration in nutrient management trend effects should be extended research into the feasibility of developing fertilizers that are designed to reduce pollution effects. More attention should be given to developing the qualitative (vs. quantitative) attributes of nutrients as their aggregate environmental effects become more serious.

Crop Production - Pesticide Management. Leading research needs directed toward the reduction of pesticide pollution include efforts to improve aerial application techniques and formlations "non-drift" to develop biodegradable pesticides, and to design integrated control systems to reduce chemical use.

Feedlot Production - Residual Disposal Management. Research should be directed toward reducing the concentrations of copper, arsenic, and sodium stemming from feedlot rations since the use of feedlot manure in land applications results in the environmentally adverse runoff of such chemicals.

Ecological Impact Research Needs

Ideally, agriculture's ecological impacts should be assessed holistically with detailed quantitative estimates made regarding such receptor characteristics as assimilative capacities, organisms present, and end-uses. The lack of data and understanding of the relationships among agricultural practices precludes such a quantitative evaluation; consequently, this study's assessment was based largely on professional judgements focusing on each individual trend. While the ultimate ecological impact of the agricultural production system is the result of the effects of the accumulation of practices, many of the trends can be examined relatively independent of other practices.

Crop Production - Soil and Water Management. A number of research needs were identified in soil and water management. The most apparent involve the determination of the ecological effects of the increased pesticide use attendant upon the expanding utilization of no-till and reduced tillage. While run-off nutrient loss will be significantly reduced under these practices, pesticide use is expected to be increased substantially. The identification of the effects of this increase is one of the most pressing needs in the agriculture sector. Other needs in soil and water management concern the determination of the effects of maintenance management of terraces and grass waterways for wildlife habitat and of the effects of salinity on human health (in irrigated regions) and animal populations.

Crop Production - Nutrient Management. Ecological effect research is needed to determine the long-term effects of leaching of nitrogen with other ions into the soil profile. New fertilizer technology is expected to be developed, particularly in formulations, e.g., microencapsulation and biological inhibitors of nutrification, and their effects should be assessed.

Crop Production - Pesticide Management. Research should continue on the effects of pesticides on human health, especially that investigating such effects when pesticides are properly used. As new pesticides are developed, ecological effect research should assess their use, and attention should be directed toward the effects of agents on non-target organisms, particularly those involving predators and parasites.

Feedlot Production - Residual Disposal Management. Ecological effects research should determine the results of the land application of feedlot wastes. Of most need are documentations of the effects of high sodium deflocculation and of the long-term effects of nitrate leaching.

Range and Pasture Management. Research needs are most apparent in two particular areas: the ecological effects of chemicals used for land renovation and the effects consequent to the introduction of new forage species.

B. Silviculture Sector Research Needs

Exhibit III-2 presents the research needs most germane to silviculture. These needs are categorized as were those for this study's agriculture sector.

Production Efficiency Research Needs

Silviculture production efficiency has resulted from a greater use of modern equipment, a better utilization of timber, more intensive management, and improved technology in timber growing. These developments, many having both beneficial and adverse environmental effects have promoted a better balance between timber production and environmental protection. However, since much of the technology associated with the use of modern equipment has worked to the detriment of the environment, EPA should initiate research which would monitor the environmental effects of production efficiency improvements. (This study recognizes, of course, the responsibility of the U.S. Forest Service in this area.)

Research needs related to increased production efficiency have been identified in three management areas: harvest management, stand control and damage control.

Harvest Management. Silviculture productivity has been improved through an increasing utilization of the total biomass, principally in the South where the utilization of roots, branches, and foliage from the younger timber, relatively free of defects, has been profitable. Research should determine the optimum level of such utilization which would reflect both its long-term economic benefit and its associated environmental damages.

Stand Control Management. Silviculture production utilizes the early reestablishment of timber species, and the extensive use of mechanical equipment during site preparation, especially in the South, to further such reestablishment. Prompt reestablishment is desirable, but some techniques have frequently proved to be environmentally disruptive. Research should determine the optimal balance between the requirements of species regeneration and environmental need.

Damage Control Management. A significant need for ecological effects research within the damage control management area recognizes the potential impact consequent to uncontrolled fires. A need is apparent to develop effective means of identifying fire danger, of predicting fire behavior, and of determining corrective actions which will have the least disruptive ecological effects.

Exhibit III-2. Summary of silviculture sector research needs by trend and research category

Silviculture Management Area/Trend	Production Efficiency Research Needs	Pollution Measurement Research Needs	Pollution Reduction Research Needs	Ecological Impact Research Needs
HARVEST MANAGEMENT				
Access			Determine minimum road standards (cut, fill, bed width, ballast) compatible with road use needs. Develop equipment designed to minimize soil disturbance.	Determine relative effects of minimum road standards versus those in practice today. Determine effects on site quality of roads abandoned to revert to forest after use.
Extraction			Determine needs by region of equipment innovations that can accomplish harvest at minimum environmental costs consistent with economic considerations. Determine methods of reducing pollution (soil disturbance, detachment, and transport) for new logging equipment	
Utilization	Determine optimum level of utilization of biomass in commercial forests and means of projecting environmental effects under varying cutting levels.	Determine sediment loadings in stream from various levels of biomass utilization.	Determine kinds, volumes, and sizes of material that should be left on site to aid in controlling pollution resulting from varying levels of utilization.	Determine effects of alternatives in level of utilization of biomass on the aquatic and terrestrial systems. Determine effects of increasing utilization on nutrients in the ecosystem.
STAND CONTROL				
Site Preparation	Determine minimum amount of site preparation required to meet requirements for establishing regeneration.	Determine level of pesticide residues in media from chemical treatments in site preparation.	Determine method or combination of methods most efficient or suitable for environmental conditions. Determine the extent of reduction of environmental damages possible by alternative methods or combination of methods. Determine which equipment results in least pollution effect and which causes the most.	Determine the ecological effects of herbicides used in site preparation; i.e., reaction of soil biomass to chemicals, volatization of chemicals in atmosphere. Determine long term ecological effects of extensive drainage and phosphate loadings in preparing swamps for planting pine in Southeast.
DAMAGE CONTROL				
Fire Control	Develop more effective means of identifying fire danger and determining fire behavior.			
CUTTING SYSTEMS				
Clear Cutting				Evaluate long term effects of clear cutting effects on terrestrial systems.

Pollution Measurement Research Needs

Harvest Management. Consequent to the expected significant increases in silviculture's utilization of the biomass, surface runoff, soil loss, sediment loadings, and nutrient losses will vary by differing levels of intensity and will have correspondingly differing environmental effects. The potential effect on the eco-system of stream sediment loading makes research necessary to measure such loading for the various levels of biomass utilization.

Stand Control Management. Chemical site preparation treatment may be preferred at times to mechanical treatment because it offers less soil disturbance, a minimum alteration of surface water mechanics, and much less disruption of the nutrient cycles. Some chemicals are usually applied only once in a 30 to 100 year rotation, pesticide effects are generally expected to be minimal; however, to determine the long-term effects of pesticide applications, research should determine the level of pesticide residues in the media resulting from chemical treatment associated with site preparation.

Pollution Reduction Research Needs

A primary concern of EPA is the identification of economically feasible and socially acceptable alternatives in silviculture which will help prevent and control adverse environmental effects. Research in this area is very closely related to that of production efficiency, since, in many cases, reductions in pollution result directly from increases in efficiency. Specific needs in this category have been identified in two silvicultural management areas.

Harvest Management. Environmental effects research needs are apparent for both extraction and utilization practices. Innovations in extracting equipment technology have frequently been developed at the expense of the environment; consequently, research is needed to design equipment, particularly logging equipment, that will minimize environmental damages. Such research should address regional requirements since these may vary substantially among regions. Research is needed, also, to determine the optimum levels of materials utilization (i.e., kinds, volumes, and sizes) in order to minimize the adverse environmental effects of such utilization practices. An additional research need should focus on developing minimum access road standards reflective of industry needs and environmental requirements.

Stand Control Management. Research is needed to ascertain which of the methods or combination of methods -- mechanical, chemical or burning -- causes the least short-term and long-term environmental damages. Each method has both advantages and disadvantages in economic efficiency and environmental effects. The extent of damages associated with each of the alternatives should also be determined to facilitate the development of controls to reduce the pollution effects of site preparation. Such research should determine the equipment that would have the least environmental impact.

Ecological Impact Research Needs

An ecological assessment of trends in silviculture was an important objective of the study and was largely based on research literature. On the whole, the literature did reflect a broad and effective coverage of silviculture's ecological effects. However, several research needs were apparent.

Harvest Management. Ecological impact research is needed regarding both access and utilization practices. As discussed above, road standards need to be modified to reduce associated adverse effects and research should be conducted to determine their ecological effects. The increasing trend towards greater utilization of the total biomass reflects significant improvement in production efficiency (primarily in the East); however, the effects of sedimentation, turbidity, and thermal pollution resulting from these practices are largely unknown. Research should, then, address the ecological effects of utilization practices and should examine their effects under different levels of intensity. An additional and important research need is one that would determine the ecological effects consequent to industry's abandonment of forest access roads in harvested areas. Specifically, research should determine the characteristic of the subsequent erosion and its ecological effect.

Stand Control Management. Two site preparations research needs were identified. As indicated previously, the levels of pesticide residues resulting from chemical treatment are not widely known. As these levels become established, research should continue on their ecological effects and should include an examination of the reaction of the soil biomass to chemicals and of the volitalization of chemicals in the atmosphere. Secondly, research is needed to determine the long-term effects of extensive drainage and phosphate loadings, resulting from the preparation of wetlands for tree planting, e.g., for planting pine forests in the Southeast.

Cutting Systems Management. Ecological effects research is needed to determine both the short and long-term effects of clear cutting systems and selective cutting systems. A belief of this study's silviculture-panel was that important differences exist among and within regions in terms of soil types, topography, climatic conditions, type of timber, and other factors which affect the optimal cutting system for a given location. Both short and long-term ecological effects need to be assessed since logging and reforestation practices will differ for each type of cutting system.

SECTION IV

POLICY ISSUES

One objective of this study was to identify policy issues associated with the environmental implications of trends in agriculture and silviculture. This section identifies those policy issues germane to the trends and subtrends as presented in both Phase I (Volume I) and Phase II of this study. These policy issues are the Contractor's assessment of prospective issues; they do not necessarily represent the views of the U.S. Environmental Protection Agency (EPA). The specific policy alternatives described are only suggestive of options which might be implemented to forward policy goals.

EPA has broad authority to establish controls for nonpoint sources (NPS) of pollution in both agriculture and silviculture. For example, Section 208 of the Federal Water Pollution Control Act. (P.L. 92-500) requires that state and local regulatory and other programs be developed to control NPS water pollution. Plans developed pursuant to Section 208 must set forth procedures and methods to control, to the extent feasible, the nonpoint sources of pollution. Furthermore, Section 208 programs are to be implemented in concert with Section 201(c) which further requires that, to the extent practicable, waste treatment management shall provide control or treatment of all point and nonpoint pollutants.

Within such a legal basis (and others, i.e., the National Pollutant Discharge Elimination System and the irrigated return flows regulations) for establishing regulatory and other programs, it is pertinent to consider--given an understanding of trends and probable developments in agriculture and silviculture--an array of potential controls which may emerge in view of pending legislative requirements to EPA regarding effective NPS pollution control.

Generally speaking, agriculture's and silviculture's nonpoint sources of pollution are subject to

(1) the control or treatment of wastes generated by production systems,
(2) the control of polluting inputs (including land), and
(3) the control of management practices to reduce pollutants generated.

Policy issues arise, then, as a direct consequence of considering public (vs. private) measures to influence any or all of these control approaches. Relevant policy issues are, that is, inherent in these fundamental questions: "What control or treatment of wastes should be imposed on agriculture and silviculture production systems?" "What controls should be placed on the use of polluting inputs, including land?" "What controls should be placed on the utilization of management practices?"

Many policy-related instruments may implement an NPS control plan: for example, Regulation, Education, Economic Incentives, and Public Investments. However, this study's analysis seeks not to identify specific implementation alternatives; rather, the study identifies only the policy areas in which issues may emerge in agriculture and silviculture as a result of the environmental implications analyzed in this study. Further analyses are needed in order to determine whether effective and practicable policy instruments could be developed and implemented.

A. Agriculture Sector Policy Issues

Within the agriculture sector, as with other nonpoint sources of pollution, it is difficult to maintain effective, practicable controls over wastes from disperse production locations; consequently, relatively more attention has been given either to the control of polluting inputs or to the control of management practices to reduce pollutants. This study, also, focuses attention on policy issues associated with the latter two forms of control.

Exhibit IV-1 summarizes the agricultural subsectors' (Exhibit column 1) potential policy issues (Exhibit rows) as categorized by types of control (Exhibit columns 3, 4, 5). This summary pertains explicitly to the potential controls which are directly linked to the major environmentally-related trends of this study--either Phase I or Phase II. Additional policy issues outside of the scope of this study are not assessed even though such policies may have consequential environmental implications. For instance, above-normal export demand, though not within the scope of this study, can be a consequential determinant of the impact of production systems. An unusually high and prolonged export demand can result in a dramatic increase in land, nutrient, and pesticide use great enough to cause measurable effects on the environment. A definitive survey of policy issues would, of course, consider such relationships.

The following descriptions of policy issues, as outlined in Exhibit IV-1, contain both a brief summary of pollution problems inherent in particular subsectors of agriculture and an explanation of their prospective policy-related NPS control issues/problems. The policy issues are categorized by (1) control of wastes, (2) control of inputs, and (3) control of management practices.

Crop Production Subsector - Soil and Water Management

Water runoff and its associated soil erosion are the main contributors to agriculture's NPS pollution. Soil is transported by the runoff and is itself (as sediment) a pollutant causing turbidity and deposition problems in water channels and receptors. Additionally, such sediment is a carrier of attached pollutants: nutrients (especially phosphates), pesticides, and soil minerals. Soluble materials, such as nutrients (especially

Exhibit IV-1. Summary of agriculture sector policy issues by management function and basic policy area

Agriculture Subsector/ Management Function	Basic Policy Area		
	Control of Wastes	Control of Inputs	Control of Management Practices
	A. AGRICULTURE SECTOR		
Crop Production Subsector			
Soil and water management	Sediment, salinity, nutrients, pesticide residues, crop residues	Land use, water resource use	Runoff and erosion control; conservation tillage; improved water application; wind erosion control; crop sequencing
Nutrient management	Nutrients	Fertilizer resource use; development of improved fertilizer; development biological nitrogen-fixation sources	Soil-plant analysis; methods of nutrient application; other
Pesticide management	Pesticide residues	Pesticide resource use; development of new biological and chemical pesticides; improvement of seeds and plants	Scouting and integrated controls; improvement of pesticide application methods and timing; other
Feedlot Production Subsector 1/			
Residual disposal management (off-site)	Organic material, nitrates, microorganisms	Land use, off-site disposal limitations, feedlot size	Alternative residual disposal; feedlot size
Range and Pasture Management Subsector 1/			
Grazing management	Sediment, nutrients, organic material, microorganisms	Land use	Grazing practices and stocking rates
Renovations and improvements	Sediment, nutrients, pesticides	Land use, fertilizer and pesticide resource use, equipment use, controlled fire use	Range and pasture renovation; range and pasture improvements; using increased resources; other

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1/ Within the feedlot and range and pasture subsectors, management areas are not all inclusive. Only the most environmentally significant areas, and with feedlot production, only management areas directly related to non-point source control are considered.

nitrates), pesticides, and saline minerals, and suspended materials, such as crop residues, are also transported in water runoff. The control of runoff and erosion is, therefore, perhaps the most critical environmental problem in the agriculture production sector.

Control of Wastes. The direct control or treatment of such residuals associated with runoff and erosion have usually been regarded as infeasible because of the wide dispersion of agriculture's discharge locations. In some instances, however, such as with irrigation return flows, collector channels have been established and waste residuals have been considered as point sources subject to EPA point source controls. Perhaps, in other special cases, drainage conditions exist such that other collector systems could also be devised to consolidate agricultural waste flows--systems which might be treated as point sources subject to regulation. Generally, however, public involvement would be required both with structures planning and development and with treatment processes.

Control of Inputs. Soil and water management implies, specifically, the control of either land use or water resource use. That is, for example, lands with known runoff or erosion problems, such as land with steep slopes, highly erodable soil structure or flood site locations may be restrained in terms of crop use or cultivation practices. Where such conditions and their attendant problems are identifiable, national land use regulations may be considered feasible policy issues as a means of lessening the overall detrimental effects of using such marginally advantageous sites. Water resource use, especially in irrigated crop production, may also be controlled. A policy issue germane to water resource use can be a reduced subsidization of irrigation, a reduction which would, by increasing the cost of irrigation, result in the more intensified and judicious management and use of water resources.

Control of Management Practices. In general, many current and prospective agricultural practices are directed primarily toward improved soil and water management. A group of specific runoff and erosion control practices such as contour farming, terracing, grass waterway construction, and narrow row cultivation are important to controlling runoff, reducing erosion, and lessening the detrimental effects of the associated pollutants. Conceivably, more can be done to foster the use of runoff and erosion control practices.

Additionally, other trends and developments that were assessed in this study are primarily associated with improved soil and water management. Conservation tillage methods, such as reduced tillage and no-till, show a high potential for reducing erosion and conserving water--thereby lowering pollutant loadings. Unfortunately, some offsetting factors are that more pest problems occur and less reliable yields are obtained. The use of more pesticides is common, and, hence, an increased pollution potential exists. On balance, the optimum conservation tillage practice for a given farming situation remains unclear at this time. More research with this method of soil and water management is clearly needed before specific policies are adopted.

Water application methods in irrigated crop production may also be developed further to improve the associated environmental effects. Already, return flows of irrigation tailwaters are being reduced, recycled and/or treated as point sources. However, salinity build-up in the soils is a major problem in some areas, and heavy irrigation rates to leach salts from the soil are essential to maintain crop productivity. Again, counter-balancing effects on either the water resource or the soil resource exist, and thus, an optimum management practice cannot be uniformly given. Nonetheless, broad policies to promote effective management practices in water application, in particular, and in soil and water management, in general, are relevant. Such policies must recognize interactions among environmental media, however.

Crop Production Subsector - Nutrient Management

Nutrient losses from agricultural activities into surface water and groundwater are a major environmental concern due primarily to eutrophication effects, and, also, to toxicological impacts in some cases, e.g., nitrates in groundwater. In the future, fertilizer use is expected to increase substantially in order to achieve projected crop production; and, control of residual nutrients into water receptors will likely continue as a major problem.

Control of Wastes. Runoff treatment to reduce nutrient levels is not generally regarded as feasible. Even in special cases where runoff can be collected, costly treatment facilities, probably publically subsidized, would be needed; hence, it appears most practical to consider other control policies.

Control of Inputs. A more accessible means of nutrient runoff control is to control fertilizer resource use. Some type of restriction or condition could be placed on fertilizer use in various farming situations, e.g., restricted per acre fertilizer rates under given conditions; however, such policies should carefully consider the economic and environmental trade-offs because indiscriminate fertilizer-use control may limit desired growth.

For example, restrictions on fertilizer use may reduce crop production per acre, increase production costs, cause a more extensive (vs. intensive) agricultural production, and require high administrative and enforcement costs. On the environmental side, nutrient levels in surface and groundwater may be reduced (unless significantly more extended production occurs), although the environmental impacts of such reductions in nutrients cannot be accurately estimated. Other forms of control in fertilizer use might include improved formulations, e.g., use of fertilizers that contain nitrate inhibitors or controlled release chemicals. On balance, great care must be exercised in any policy to control the use of nutrients because alternative production-paths may result in equally serious environmental problems.

Control of Management Practices. This third type of general policy alternative has various options for reducing nutrient loss. For example, best management practices could be developed to combine such factors as timing, placement, form, number and application method (as is now being developed in general through EPA's BMP system planning). Such practices would generally be directed toward the most efficient crop utilization, although this objective is not inconsistent with improving nutrient losses since current practices often involve heavy, single fertilizer applications primarily for operator-ease. Such applications may be subject to greater nutrient loss than would be multiple applications of lesser amounts per application. Another example of a management practice control option would be the fostering of soil-plant analysis to enable the farm operator to more precisely determine the nutrient requirements of his growing crops. This practice would better balance crop needs and reduce excessive fertilizer applications where applicable. In some cases fertilizer rates may actually need to be increased, but, as outlined above, additions of fertilizer would be dispersed in time, and the nutrients applied would presumably be more readily available for uptake during the growing period with less runoff potential during a given time interval.

Emerging developments such as biological nitrogen-fixation sources and improved fertilizer formulations should continue to be monitored as potential means of controlling fertilizer resource use and/or best management practices. In the short-term, however, effective nutrient management will mostly involve careful execution of selected practices; the execution of a practice may indeed be as important environmentally as the selection of the practice itself.

Crop Production Subsector - Pesticide Management

Pesticide residues are widespread in the environment, stemming largely from agriculture's use of thse chemicals to maintain and improve crop production and quality. These residues are found in the air, soil, water supplies, and the human food chain, and have been responsible for adverse effects on non-target wildlife species. Residues enter the environment through drift during application, by volatilization after application, and by transport via surface water runoff and sediment. Certain pesticides will also be leached into ground water supplies. While the debate continues over the actual hazards of pesticide residues in the environment, these residues should be controlled to reduce potential dangers. Ideally, pesticide management should be for optimal crop production with minimal adverse effects on the environment.

Control of Wastes. The direct control of pesticide residues in all media receptors, i.e., soil, air and water, would be difficult, perhaps impossible. Though not yet economically practical, only surface water treatment to remove pesticide residues appears technically possible. For the most part, the greatest potential for adverse effects occurs after pesticide application during the first run-off event. Prospective on-site treatment of pesticides in this first run-off could be beneficial to the aquatic ecosystem, and treatment at some later point, after dilution or partial degradation, would likely be much less effective. This time and event-dependent relationship, plus the dispersed location of discharge points and the difficulty of pesticide control treatment, makes direct control seem economically infeasible.

Control of Inputs. Pesticide resource controls have been a policy alternative regularly utilized by EPA in the past, especially for toxic substances. Most commonly, certain pesticides have been banned from agricultural use, or are available only for restricted uses. This action has often resulted in the use of alternative pesticides by farm operators, and, such pesticides may either be less effective or require more active material application per acre to achieve adequate control. Even so, the banned materials are presumed to have caused (or will have caused) even greater environmental damage. In the future, the banning of additional pesticides is viewed as a viable policy option.

Other forms of restrictions on pesticide use would be less severe, yet perhaps more environmentally beneficial. Controlling the rates of use or the specifying of conditions of use, including the licensing of pesticide applicators as is now being accomplished under FIFRA, may become more widely feasible in the future. A difficulty with such an alternative is simply its enforcement and the potentially high administrative costs. However, the use of integrated pest control management, i.e., use of chemical-mechanical-biological management systems, is expected to increase in the future; conceivably, with restricted (rather than banned) pesticides, more cost-effective and environmentally acceptable management practices could be developed.

Alternative formulations of pesticides are regularly being developed which offer improved pest control and less active material per application: formulations of surfactants with herbicides, foaming agents, and uniform granular particles. In general, such alternative formulations are expected to reduce pesticide requirements per application because of their improved effectiveness. These formulations often offer the advantage, also, of less drift problems during application.

Control of Management Practices. Current agricultural trends in pest control management are amenable to policy controls. For example, the expected increase in scouting and integrated controls will aid in reducing the use of chemical pesticides. Associated management practices such as crop rotations and the use of pest-resistant crop varieties, attractants, biological pesticides, and others can reduce the need for chemical pesticides.

In general, it is expected that pest control management alternatives, such as biological pest controls, will only reduce, and not eliminate, the need for chemical pesticides. Fortunately, improved chemical pesticides are also being developed which are selective against pests, more readily biodegradable, and non-toxic to man and animals. Plant-breeding improvements which increase the insect and disease resistance of crops will further aid in the reduction of chemical pesticide use.

The effectiveness of any of these alternative pest management practices will depend upon the particular crop and pests present. As an example, a farm operator might have a choice of using a chemical pesticide, a biological control, or a very resistant crop variety for control of a particular insect. For another insect problem, the only effective option might be the use of chemical pesticides. Farm operators cannot be expected to voluntarily adopt alternatives such as pheromones or attractants until it is feasible for commercial use and can be shown to be as effective as current control methods. Consequently, continued research and public education will do much to foster adoption of other pest control practices.

Feedlot Production Subsector - Residual Disposal Management

Feedlot residual disposal alternatives are: temporary storage, on-site disposal, refeeding, and off-site disposal. Off-site disposal is the only alternative considered to have significant implications for NPS control, and, thus, it is the only practice in the feedlot production subsector assessed herein.

Control of Wastes. In general, the off-site disposal of wastes is expected to result in increased concentrations of nitrates, organic material and microorganisms in receiving waters. Nitrate levels in ground water may also be increased. Unfortunately, once untreated feedlot wastes leave the feedlot and are dispersed on the land, their direct control or treatment is seldom feasible, as with crop production residuals. The costs of prior-disposal treatment facilities and their technological limitations have been prohibitive; hence, direct controls show little promise as a policy alternative at the present time.

Control of Inputs. More practical is the control of feedlot-related inputs. The land available for feedlot waste disposal may be regulated. In addition, controls might be placed on off-site disposal application rates, and, controls might be placed on feedlot size based on the amount of suitable land in the local area that is available for waste disposal.

Controls and restrictions on land use might be applicable, for example, where land has severe erosion problems or where land drains into a heavily used or sensitive water receptor. Disposal application rates can be determined for soil characteristics, topography, and method of application. Finally, feedlot-size constraints can be imposed to reflect the relative availability of waste disposal sites.

Such input restraints can be maintained by policy issues that regulate the extent and character of land sites approved for feedlot operations or waste disposal.

Control of Management Practices. Proper waste disposal application rates (also a resource use control) and methods e.g., solid or slurry, incorporated in soil or not, etc. constitute feasible management practices subject to policy issues. Continued research is needed, however, to ascertain the best management practices in this feedlot waste disposal area.

Range and Pasture Management Subsector - Grazing Management

Livestock grazing on range and pasture land generally results in increased soil erosion and runoff. Grazing livestock wastes, also, result in increased amounts of nitrate, organic material and microorganisms in receiving waters. Proper grazing management practices will minimize these pollution effects.

Control of Wastes. Policies to control or treat range and pasture grazing residues are not expected to be feasible because of the highly dispersed and expansive character of ranges and pastures. Furthermore, many persons would argue that the residuals generated are relatively insignificant when compared with other agricultural or point source wastes. These arguments suggest that the greatest policy focus should be on control of inputs or control of management practices where improper actions are evident.

Control of Inputs. Land use is the only applicable input for policy control. Land with severe topographical limitations or land having fragile soils could be excluded from grazing. Such control would reduce erosion problems and the transport of livestock wastes into receiving waters. (Stocking rates--number of animals per unit land--may also be considered as an input variable, but this is discussed below as a management practice.)

Control of Management Practices. Because grazing practices are the main management function having associated environmental effects, they are the most susceptible to control policies. First, grazing management systems are normally selected by producers, and proper stocking rates are implicit within the system. Grazing systems are either continuous or specialized. The determination and selection of a grazing system should be based on factors such as the type and location of the range or pasture, its topographical limitations, the condition of the range or pasture, and other factors (e.g., use of land for recreation or silvicultural production). The factors to be assessed in selecting the best grazing system are complex, and, for that reason, policies to control the selection of proper management practices may be applicable. The Bureau of Land Management, USDI, and the U.S. Forest Service currently provide grazing management services and controls on public lands.

Range and Pasture Management - Renovations and Improved Management

Range and pasture renovations and improvements involve practices which usually cause soil disturbances and consequent soil loss. Chemical renovations will also involve increased pesticide runoff. In these cases, however, pollutant loading increases are normally temporary, and, as revegetation occurs on the disturbed or bared soil, the loadings subside. For example, drainage and erosion control structures result in a short-term disruption, but they will eventually promote soil stability and, thereby, benefit the environment in the future. Because of the differential short-term vs. long-term effects of range and pasture renovations and improvements care must be taken in developing policy controls which might limit renovations in the short-run without adequate evaluation of the long-term effects.

Control of Wastes. The control of renovation and improvement wastes is impracticable both because of the dispersed and intermittent nature of the practices and because of their relatively short-term environmental effects. Further considerations of policy controls are, therefore, limited to potential resource use limitations and management practice issues.

Control of Inputs. Land use, pesticide use and prescribed fire use are the primary inputs that may be considered for policy control. Lands unsuited for grazing or lands with limited carrying-capacity may be restricted in use and/or renovation practices may be required. Pesticide uses on ranges or pastures may be regulated, or even banned, under adverse conditions -- much the same as is being done with pesticides in other agricultural subsectors. The use of prescribed burning for renovation purposes may be subject to controls in air quality limited regions.

Control of Management Practices. Range and pasture renovation or improvement practices may result in controversial policy issues, for though these practices generally result in short-term soil disturbances and increased pollution, they can yield improved soil stability and reduced pollution in the long-term. Careful assessments are needed to determine optimum strategies under varied range or pasture conditions. Alternative management practices include mechanical or chemical renovations and renovations through prescribed burnings. Particular attention needs to be given to any potential controls on range or pasture lands with a rough terrain or with fragile soils.

Other management practices are primarily concerned with the quality of the range or pasture vegetation. For example, improvements are being made in the nutritional quality of the vegetation, genetic developments are being pursued, and inter-seedings with improved forage varieties have been achieved. These practices will indirectly, if not directly, affect environmental quality by improving the production efficiency of the nation's range and pasture resources. Environmental control policies which foster such management practices may be feasible and beneficial.

B. Silviculture Sector Policy Issues

While certain similarities exist in pollutants generated by the agriculture and silviculture sectors, certain innate differences do exist; and thus, their policy issues are assessed separately. Differences include 30 to 100 year growth cycles in silviculture compared to the predominant annual cycles in agriculture production. Specifically, total annual levels of pollutants from the entire silviculture sector are relatively small because of the long growth cycles which require that only a relatively small portion of the total 500 million acres of timber be entered each year for any type of management.

Aesthetic and wildlife considerations, also, may become an increasingly most important part of silviculture production from the environmentalist's viewpoint. Silviculture is expected to coexist with wildlife populations, be aesthetically pleasing, and, at the same time, provide the nation's timber supply. These multiuse purposes for forest lands complicate the environmental assessment process.

As with agriculture, three types of policy controls are discussed within the silviculture sector: control of wastes, control of inputs, and control of management practices. A general summary of potential policy issues, categorized by type of control, is shown in Exhibit IV-2. This summary includes both the Phase I and Phase II environmentally-related trends in silviculture identified in this overall study.

Silviculture Production Sector - Harvest Management Function

The principal pollutant generated by harvest management practices is sediment. Since forest areas are seldom fertilized or treated with chemical pesticides on a regular basis, sediment is usually not a carrier of application nutrients or pesticide residues. Other environmental effects of harvesting include thermal pollution, altered water flow patterns, forest residues, wildlife disruptions, and aesthetics. While pollutants resulting from harvest activity may contribute only a small part to aggregate nonpoint source pollution, the effect of large sediment loadings or wildlife disruptions in isolated harvest areas can be very damaging to the ecosystem in that area. Hence, harvest management, in general, should be evaluated to improve the control of generated pollutants as well as for the control of ecological effects.

Control of Wastes. The direct control of sediment generated by harvesting practices is not regarded as feasible, primarily because sediment loadings from silviculture activities may be rather insignificant and surface waters receiving sediment loads will change each year with harvest activity. Forest residues remaining after harvest can be collected for future use or for controlled burning.

Control of Inputs. Harvest management inputs include land use and equipment use. Associated policy issues can designate certain sections of a forest area as critical habitat for certain endangered species, and, therefore, restrict harvesting. Land with steep terrain or fragile soils could be withdrawn from road constructions. Harvesting equipment could also be banned for use in certain terrains and forest types, or conversely specific practices could be required to ensure minimal environmental impacts. Such harvest management input contols could be readily adopted on public lands; private holdings might be similarly managed, with greater complexity however, if necessary.

Control of Management Practices. While practices can clearly be established and identified in agriculture to control runoff and erosion or to control nutrient losses, these equivalent practices do not exist in silviculture. Rather, a series of broad functional steps (trends) are involved in harvesting management: access to timber, cutting systems, log extraction methods, and utilization of forest biomass. Each of these steps has associated practices that must be used during the harvesting of a forest. Management practices for harvesting are not considered as control measures, themselves; rather the control of management practices for harvesting implies the proper use of equipment, use of well-engineered plans, and proper execution of management practices to cause the least environmental damage. In certain cases, as with cutting systems, a selected management

Exhibit IV-2. Summary of silviculture sector policy issues by management function and basic policy area

Silviculture Management Function	Basic Policy Area		
	Control of Wastes	Control of Inputs	Control of Management Practices
		B. SILVICULTURE SECTOR	
Harvest management	Forest residues, sediment	Land use, equipment use	Access to timber resource; cutting system; log extraction; utilization
Stand control management	Sediment, nutrients, forest residues	Fertilizer resource use, land use, equipment use, control burning use	Site preparation; growth enhancement stand conversion; stand establishment
Damage control management	Forest residues, pesticide residues, sediment, nutrients	Land use, pesticide resource use, controlled burning use	Fire control; pest control

practice may be more desirable for specific terrains for forest species. In summary, the proper execution of a given management practice is usually of greater concern in harvest management than is the selection of the management practice, *per se*; however, some exceptions are apparent, which may be subject to effective policy control, such as with cutting system selection.

Silviculture Production Sector - Stand Control Management

Stand control management practices often result in significant soil loss and sediment loadings in receiving waters. Since fertilizer applications are required with some of these practices, nutrient loss may also accompany soil movement and surface runoff. Additionally, other environmental effects of stand control practices are impaired aesthetic values, unsightly forest residues, and wildlife disruptions (often irreversible). Thus, the primary objective of stand control management should be the achieving maximum forest growth for future harvest while reducing sediment loading in receiving waters and minimizing ecological disruptions.

Control of Wastes. The direct control of wastes or residuals associated with stand control involves the control of sediment, nutrients, and forest residues. Direct control or treatment of sediment and nutrients is expected to be economically infeasible because sediment loading locations are very diverse and will change as stand control management moves from one site to another after successful regeneration. Direct control of forest residues is already being accomplished by the collection of residuals remaining after site preparation, thinning control or other stand control measures. These residues, after collection, may be marketed or burned, under controlled conditions, as a means of removal.

Control of Inputs. Stand control management practice inputs include the two as discussed for harvest management -- land use and equipment use, plus two additional inputs -- fertilizer use and controlled burning use. Depending upon the terrain, harvest methods, and desired forest species, each of the four inputs could have restraints placed on their use. For example, large applications of phosphate are needed on some forest soils in the South for successful regeneration. Should phosphate concentrations in surface water greatly increase, phosphate application could be restricted on a per acre basis. Another example of input control would involve land use in the conversion of wetlands to productive forests. If these wetlands were to be designated as critical habitat for winter waterfowl, then further conversion of this land into forest area could be restricted.

Control of Management Practices. Four trends -- site preparation, growth enhancement, stand conversion, and stand establishment are considered stand control management practices. Each of these has a number of associated practices that can be used singly or in conjunction with other practices to achieve optimum forest regeneration; however, as with harvest management practices, the proper execution of a given management practice is often of greater concern than is the actual selection of a management practice. For the most part, a stand control management practice is primarily designed not to specifically reduce a pollutant or minimize certain ecological effects but to be effective in some area of stand control. With careful, conscientious execution, pollutants and other ecological effects resulting from these practices can be reduced.

Site preparation can be accomplished by several means: log extraction method, mechanical preparation, burning prescription, chemical treatment, fertilizer treatment, and soil moisture control. Burning prescription or chemical treatment might be preferred practices in forest areas with steep terrains, fragile soils, or heavy rainfall; with other soils and forest types, any of the site preparation methods, with proper planning and execution, could be used with minimal pollutant loading effects.

Growth enhancement, stand conversion, and stand establishment also offer some choice in practice alternatives. Again, proper execution is often the most important aspect in reducing pollutant loadings and ecological effects.

Silviculture Production Sector - Damage Control Management

The third area of selected silviculture management functions is the control of fire, insects, and disease to reduce the potential for forest damage. Pesticide residue levels in receiving waters are expected to increase with chemical control of insects and disease. Mechanical treatment used to eliminate infested material will result in forest residues and in minor soil disturbances. For the most part, fire control and prevention methods will have relatively insignificant environmental impacts. Controlled fire will result in air pollution and in temporary increases in the nutrient levels of receiving streams.

Control of Wastes. Forest residues, sediment, nutrients, and pesticides partially discussed previously, are associated with direct control of residuals resulting from damage control management. Additionally, collection and/or controlled burning of forest residues may result in beneficial aesthetic effects, and as a management practice, the elimination of these residues will reduce the potential for hazardous forest fires.

Control of Inputs. As with the other management practices, certain forests are or could be designated as having critical habitat or as having such topographical limitations that restrictions could be placed on land and/or resource use. Fire control practices, a third damage management practice input, involve improvements in prevention and detection methods and in the use of controlled fire to reduce the potential of disastrous fires. Generally, these practices will have relatively insignificant environmental impacts, and the control of management practices will be for more efficiency in their functions rather than for the control of environmental pollutants.

Control of Management Practices. For insect and disease control, only two options exist for management practices: control by mechanical treatment or control by chemical agents. Since each can result in pollutants of some nature, careful planning and execution of either practice are necessary to reduce potential environmental pollutants. Some alternatives do exist, however, in the control of insects and disease. If, for example, a properly applied insecticide has adverse effects on non-target wildlife or on aquatic ecosystems from aerial drift or surface runoff, then the best management might involve using mechanical treatment in that area, even though forest residues and potential soil loss will occur. Additionally, pest control with such biological agents as pheromones, repellants, or natural predators may become another alternative by 2010. This practice might be preferable to chemical or mechanical control in some areas.

SECTION V

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APPENDIX A

DETAILED ENVIRONMENTAL ASSESSMENT OF SELECTED AGRICULTURAL TRENDS AND THE ECOLOGY WORKSHOP EVALUATION SUMMARY

The Contractor prepared a background summary report of selected Phase II agriculture trends and subtrends which was submitted to an ecology workshop panel for their review prior to the workshop. Based upon this summary, the workshop identified and rated the ecological effects of each subtrend in three areas: aquatic life, terrestrial life, and human health.

A. Background Summary Report - Agricultural Sector

Only selected trends and their subtrends, from Phase I, as shown in Exhibit A-1, were chosen for the Phase II study. In particular, 10 trends and 41 subtrends are contained herein for detailed analysis. The Contractor conducted a thorough literature search for each subtrend's extensiveness of use, productivity effects, changes in resource use, and pollutant changes by media. Quantitative data were sought and included when available in the summary report. A worksheet was prepared for each subtrend showing the Contractor's research findings, conclusions, and references. This information was provided to each workshop participant in the background summary report and summaries are contained in the Appendix immediately following.

B. Evaluation

As mentioned, the principal task of the ecology workshop was to determine and rate the ecological effects of each agriculture subtrend in three areas: aquatic life, terrestrial life and human health. Ecological effects could be beneficial (+) or adverse (-) on a scale of 1 to 5, where 1 = minor, 2 = limited, 3 = moderate, 4 = important and 5 = major. A consensus judgment was sought by the workshop for all ecological ratings. Ratings were determined for both the short-term, 1985, and long-term, 2010, relative to 1976. Worksheets showing the ecological effects, ecological ratings, and related ecological research needs for each subtrend are also contained herein in conjunction with the background summaries according to their trend-subtrend number as shown in Exhibit A-1.

Exhibit A-1. Summary of selected Phase II trends and subtrends in agriculture

Sector/Trend	Subtrend
	A. AGRICULTURE SECTOR
Crop Production	
1. Runoff and Erosion Control	1.1 Contour farming/contour strip cropping
	1.2 Terraces and grass waterways
	1.3 Optimizing time of operations
	1.4 Narrow rows
	1.5 Winter cover crop
2. Conservation Tillage	2.1 No-tillage
	2.2 Reduced tillage
3. Improved Water Application	3.1 Furrow basins
	3.2 Land grading
	3.3 Sprinklers
	3.4 Recycling and controlling tailwater
	3.5 Irrigation scheduling and efficiency
4. Improvement Seed and Plants	4.1 Weather resistance
	4.2 Salt resistance
	4.3 Production efficiency
	4.4 Disease and insect resistant
5. Scouting and Integrated Controls	5.1 Surface scouting
	5.2 Remote sensing scouting
	5.3 Integrated controls
6. Development of New Biological and Chemical Pesticides	6.1 Micro-encapsulated
	6.2 Systemic pesticides
	6.3 Surfactants for herbicides
	6.4 Bio-degradable pesticides
	6.5 Alternative formulations
	6.6 Juvenile hormones
	6.7 Pheromones
	6.8 Sterile males
	6.9 Predators and parasites
7. Methods of Nutrient Application	7.1 Foliar application
	7.2 Multiple application
	7.3 Fall application
	7.4 Liquid fertilizer
	7.5 Aerial and floater application
	7.6 Improved nutrient placement
	7.7 Irrigation application
8. Soil Plant Analysis	8.1 Soil plant analysis
Feedlot Production	
9. Alternative Residual Disposal	9.1 Off-site disposal- solids and liquids
Range and Pasture Management	
10. Grazing Practices and Stocking Rates	10.1 Continuous grazing
	10.2 Specialized grazing
	10.3 Complementary forage seedings
	10.4 Controlled livestock grazing

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 1. Runoff and Erosion Control

Subtrend: 1.1 Contour farming/contour strip cropping

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	2010	Factors/Rationale
Aquatic	+1	+4	↓turbidity; ↑species diversity; low E in 1985; ↓pesticide residues
Terrestrial	+1	+3	↓erosion; retention of nutrient cycles
Human Health	0	0	No significant effects

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Extensiveness of contouring in 1985 (over 1976 use) will be low, but will increase by 2010. Beneficial aquatic effects result from decreased turbidity and pesticide residues in surface water. Species diversity will also increase in the equatic ecosystem. Decreased erosion and retention of soil nutrient cycles will have long term beneficial terrestrial effects. Since pesticide residues at current levels in drinking water are not known to be a human health hazard, reduction of pesticide residues will have no significant human health effects. However, if pesticide residues are later determined to be dangerous at current levels, then human health effects would be beneficial.

(2) Research needs:

a. Continued research is needed on pesticide residues and their effects on human health.

b. Additional research is also needed to determine the effectiveness of contouring on reducing nutrient and pesticide losses.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 1.1. Environmental assessment of selected agricultural trends: Crop Production
Trend: 1. Runoff and Erosion Control
Subtrend: 1.1 Contour Farming/Contour Strip Cropping

Page 1

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Acreage of crops farmed on the contour or strip cropped decreased 25% between 1964 and 1969 and continued to decrease slightly to 1976. Contour farming is more widely used in nonirrigated crop production than in irrigated crop production.	1. Evaluation Workshop Ratings-- Panel 1: 1976 _3_; 1985 _4_; 2010 _5_. Panel 2: 1976 _1_; 1985 _1_; 2010 _1_. 2. Grain and Row Crops on Contour-- 1964 = 20,254,000 acres 1969 = 14,572,000 acres Strip Cropping for Erosion Control-- 1964 = 16,029,000 acres 1969 = 12,447,000 acres	1. Dev. Planning & Res. Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977. 2. U.S. Bureau of Census, Census of Agriculture, 1969. Volume 5. Special Reports, Part 15, Graphic Summary, 1971.
Productivity	Land suited to contour farming techniques will have production levels comparable to conventional methods. Decreased income may result from hay rotations in strip cropping. Land base will remain the same.	3. Yields from contour farming will be 0.1% less than conventional methods. 4. Hay rotations in strip cropping can decrease profits.	3. Putman, J., Stripe, S., and McDivitt, J., A Summary of the Linear Programming Analysis for the Maumee Level B River Basin Study, preliminary working paper, 120 pp., 1977. 4. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency, Control of Water Pollution from Cropland, Volume 1, Report No. ARS-H-5-1, Washington, D.C., 1975.
Resource Use	Fertilizer and herbicide use remain constant. Insecticide use will remain constant to very slight increases (.02%).	5. Fertilizer and herbicide use remain constant. Insecticide use increases 0.02%. 6. Fertilizer and pesticide use do not change with contouring.	5. Reference #3. 6. Reference #4.
Pollutant Changes in Media: Surface Water Sediment	Sediment loss can be reduced substantially on moderate slopes, but much less on steep slopes. Reductions up to 50% are possible, but average reductions will be about 35%. Contour strip cropping can reduce sediment losses more than contour alone. (Note: research shows substantial loss can occur with contour watersheds with some soil types, with long slopes and/or with steep slopes.)	7. Soil loss is reduced an average of 12% with contour farming practices. 8. Contour reduces soil loss to 50% on moderate slopes, but much less on steep slopes. Contour strip cropping reduces soil loss to 50% of that in contour alone. 9. Direct run-off was reduced 32% with contouring over 9-year period.	7. Reference #3. 8. Reference #4. 9. Allis, J. A. "The Story of Two Watersheds." Journal Soil and Water Conservation 7(5): 243, 1952.

continued . . .

Exhibit 1.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Surface Water Sediment (Continued)		10. Runoff was reduced 13-16% with contour tillage.	10. Wischmeier, W.H., "Relation of Field-plot Runoff to Management and Physical Factors," Soil Sci. Soc. Amer. Proc. 30: 272-277, 1966.
		11. Contour farming on slopes with loess soil showed substantial soil losses, 17-48 metric tons/ha.	11. Burwell, R.E., and others, "Quality of Water Discharged from Two Agricultural Watersheds in Southwestern Iowa," Water Resources Research 10(2): 359-365, 1974.
Nutrients	Nutrients associated with sediment will be reduced, but reductions may not be proportional to the amount of sediment lost.	12. Practices reducing direct surface runoff and erosion will reduce nutrient transport, but reductions may not be proportional to sediment reductions.	12. Reference #4.
		13. 89% of N lost and 95% of P lost were associated with sediment (except for alfalfa).	13. Timmons, D.R., and Holt, R.F., "Relation of Nutrient Content of Water to Agricultural Practices and Natural Vegetation," on-going research, North Cen. Soil Cons. Res. Lab, Minnesota, 1976.
		14. Over 97% of N and P lost from watersheds was associated with sediment lost primarily in first 2 months after planting.	14. Burwell, R.E., and others, "Nutrient Transport in Surface Runoff as Influenced by Soil Cover and Seasonal Periods," Soil Sci. Soc. Amer. Proc., 1975.
Pesticides	Pesticide reductions will be less than that for nutrients since a greater amount of pesticide is lost through surface-water than bound to sediment.	15. Major mechanism of pesticide loss (except for chlorinated hydrocarbons) is not by transport on eroded soil particles, but with surface runoff water. The concentration on sediment is greater, but the greatest amount of loss occur with surface runoff, since there is a greater amount of water lost compared to sediment. Runoff and soil loss management practices can often reduce pesticide losses to some extent.	15. Leonard, R.A., Bailey, G.W., and Swank, R.R., "Transport, Detoxification, Fate, and Effects of Pesticides in Soil and Water Environments," pp. 48-78. In: Land Application of Waste Materials, Soil Cons. Society of Am., Iowa, 1976.
Pollutant Changes in Media: Ground Water--Nutrients-Pesticides	Loss of nutrients and pesticides through ground water will remain constant or decrease slightly. However the amount of N leached is small compared to amount that can be lost in runoff and loss of pesticides to ground water is minor with proper application rates.	16. Movement of pesticides into ground water from normal application rates is an unlikely pathway of significant loss.	16. Reference #15.
		17. Amount of N leached is small compared to the amount than can be lost in runoff.	17. Reference #4.
		18. As much as 89 to 90% of N lost is bound to sediment.	18. Reference #13 and #14.

continued . . .

Exhibit 1.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Soil	Erosion losses can be reduced up to 50% with average reductions of 1[illegible]% (See conclusions on sediment).	See research finding on sediment.	
Pollutant Changes in Media: Air	Pesticide losses through volatilization will decrease if they are incorporated into the soil by mechanical means.	19. Incorporation of pesticides into soil tends to reduce losses by volatilization and wind erosion.	19. Reference #15.

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 1. Runoff and Erosion Control

Subtrend: 1.2 Terraces and grass waterways

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+1	+3	conserve water; ↓turbidity; ↑species, ↓pesticides; low E
Terrestrial	+1	+3	topsoil saved; ↑species diversity; ↑pathways
Human Health	0	0	no known effect, based on present knowledge

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Terraces are more effective than contouring in reducing pollutants, but extensiveness of use is lower for terraces. Aquatic effects are decreased turbidity, increased species diversity, and decreased pesticide residues. Terrestrial effects are beneficial, resulting from increased vegetation on terraces and grass water waterways, increased diversity of wildlife, and more pathways for animal populations to travel. Valuable topsoil will also be retained. Based on present knowledge, there is no known human health effect. Decreased sediment in water might result in an unpleasant taste or odor in drinking water.

(2) Research needs:

a. Research is needed on the maintenance of terraces and grassways and the effects on terrestrial life.

b. Sediment standards in U.S. waters and the effect upon drinking water quality need to be determined.

c. Effectiveness of soil erosion measures in the control of nutrient losses needs continued research.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 1.2. Environmental assessment of selected agricultural trends: Crop Production
Trend: 1. Runoff and Erosion Control
Subtrend: 1.2 Terraces and Grass Waterways

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Terraces and grass waterways are not important in irrigated production, but are important for non-irrigated crops. However only 6% of all acres in 1969 had terraces. The acres with terraces in 1976 could have increased or decreased slightly.	1. Evaluation Workshop Ratings-- Panel 1: 1976 4, 1985 5, 2010 5 Panel 2: 1976 0, 1985 0, 2010 1 2. Cropland and pastures with terraces in 1969 were 16,435,000 acres.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume I, 200 pp., 1977. 2. U.S. Bureau of Census, Census of Agriculture, 1969, Volume 5, Special Reports, Part 15, Graphic Summary.
Productivity	Productivity will remain unchanged. Some land will be taken out of production by terraces and grass waterways, but will permit more extensive cropping on slopes.	3. Terraces can increase cropping intensities on slopes.	3. U.S. Department of Agriculture/ U.S. Environmental Protection Agency, Control of Water Pollution from Cropland, Volume I, Report No. ARS-H-5-1, Wasnington, D.C., 1975.
Resource Use	Fertilizer, herbicide, and insecticide use is not expected to increase (Fertilizer could increase if production per cropped acre is expected to increase to compensate for land taken out of production). However, terrace practices will not require more fertilizers. Costs and maintenance increase for terraces.	None Available.	
Pollutant Changes in Media: Surface Water - Sediment	Substantial reductions in sediment and runoff can usually be expected.	4. Reduced sediment 94-98% compared to contour Loess soil on slope. 22% of total water yield was surface runoff, 78% was base flow water. 5. Runoff from terrace field had a 20% increase. 6. Terraces usually reduce runoff and sediment. 7. Contour continuous corn on Loess soil lost 38 tons of sediment per acre compared to 1 ton - 2.9 tons of sediment per acre lost with terraces. Of total water yield, 11% was surface runoff with terraces compared to 67% surface runoff for contour.	4. Burwell, R.E., and others, "Quality of Water Discharged from Two Agricultural Watersheds in Southwestern Iowa," Water Resources Research 10(2): 359-365, 1974. 5. Richardson, C.W., "Changes in Water Yield of Small Watersheds by Agricultural Practices, Tran ASAE 15(3): 591-592. 6. Reference # 3. 7. Saxon, K.E., Sporner, R.G., and Kramer, L.A., "Hydrology and Erosion of Loessial Watersheds," ASCE Proc. Hydr. Div. 97(Hy 11): 1835-1851, 1971.

continued . . .

Exhibit 1.2. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Nutrients	Reductions in nitrates and phosphates are expected with decreased soil loss and surface runoff. Reductions could be substantial with some soils and cropping systems.	8. Total nitrogen lost in surface runoff with terraces was reduced 83-94% compared to contoured corn. Phosphorous lost in sediment was reduced 63-80% in the same system. 9. As much as 97% of N and P lost from watersheds was associated with sediment loss, primarily in first two months after planting.	8. Reference #4. 9. Burwell, R.E., Timmons, D.R., and Holt, R.F., "Nutrient Transport in Surface Water as Influenced by Soil Cover and Seasonal Periods," Soil Sci. Soc. Amer. Proc., 1975.
Pesticides	Reduction of pesticide residues in surface water could be substantial with terrace systems, since both surface runoff and soil loss are reduced.	10. Pesticides are lost on sediment and by surface runoff. The greatest amount of pesticide loss is from surface runoff. Concentrations on sediment may be higher, but a greater amount of water is lost compared to sediment. 11. Hydrocarbon and organophosphate insecticides were used on a terraced-watershed, but no detectable residues were found in runoff water.	10. Leonard, R.A., Baily, G.W., and Swank, R.R., "Transport, Detoxification, Fate, and Effects of Pesticides in Soil and Water Environments," Land Application of Waste Materials, Soil Conservation Society of America, Iowa, 1976. 11. Reference #4.
Pollutant Changes in Media: Ground Water - Nutrients	N in ground water may be reduced, based on limited research data.	12. N loss in ground water showed 20-45% reductions for a terrace watershed compared to a contour watershed.	12. Reference #4.
Pesticides	Leaching of pesticides is not likely to result in significant loss with normal application rates.		
Pollutant Changes in Media: Soil	Substantial reductions in erosion can result.	See research finding on sediment.	
Pollutant Changes in Media: Air	No change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 1. Runoff and Erosion Control

Subtrend: 1.3 Optimizing time of operations

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	2010	Factors/Rationale
Aquatic	+1	+1	E will increase by 1985; 10-20% ↓sediment; ↓turbidity
Terrestrial	+1	+2	↑wildlife food; wildlife environment enhanced
Human Health	0	0	No known human health effects

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

This subtrend assumes that spring plowing vs. fall plowing will increase by 1985. Aquatic effects result from 10-20% reductions in soil loss, decreased turbidity, and increased species diversity. Beneficial terrestrial results, besides saving topsoil, are increased winter food supply for wildlife and provision of a more structured environment for wildlife in winter. This subtrend has no know human health effects.

(2) Research needs:

a. More research is needed for effectiveness of spring plowing vs. fall plowing on flat and hilly terrains.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 1.3. Environmental assessment of selected agricultural trends: Crop Production
Trend: 1. Runoff and Erosion Control
Subtrend: 1.3 Optimizing Time of Operations

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Extensiveness is unknown; however, based upon workshop rating in non-irrigated crop production, extensiveness was moderate in 1976 and expected to increase to important levels by 2010.	1. Evaluation Workshop Ratings Panel 1: 1976 _3_, 1985 _4_, 2010 _4_	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume I, 200 pp., 1977.
Productivity	Optimizing time to solely minimize and reduce runoff can cause productivity decreases, when bad weather prevents planting. Overall productivity would likely remain unchanged, since some farmers would experience yield increases with optimum planting time.		
Resource Base	Resource base is expected to remain constant.	No research data available.	
Pollutant Changes in Media: Surface Water - Sediment	Spring planting at optimum time can reduce sediment slightly. Residues remaining through winter, can further reduce soil loss. Estimated reductions in soil with spring plowing are 10-20%.	2. Compared to fall plowing, spring plowing can reduce soil loss by 10%. However, fall plowing can be recommended with areas having very wet springs with nearly level soils of moderately fine to fine texture. Delayed spring planting and plowing beyond optimum dates can increase soil loss.	2. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency, Control of Water Pollution from Cropland, Volume I, Report No. ARS-H-5-1, Washington, D.C., 1975.
Nutrients	Slight reductions to no change are expected for nutrients in surface water.		
Pesticides	Slight reductions to no change are expected for pesticide residues in surface water.		
Pollutant Changes in Media: Ground Water	Relatively little change for nutrients and pesticides entering ground water. However, leaching of N and pesticides into ground water is not likely to result in significant losses with normal applications in most farming operations.	3. Movement of pesticides into ground water from normal applications in farming is an unlikely pathway of significant loss. 4. 89% of N lost and 95% of P lost were associated with sediment losses.	3. Leonard, R.A., Bailey, G.W., and Swank, R.R., "Transport, detoxification, Fate, and Effects of Pesticides in Soil and Water Environments, pp. 48-78. In: Land Application of Waste Materials, Soil Conservation Society of America, Iowa, 1976. 4. Timmons, D.R., and Holt, R.F., "Relation of Nutrient Content of Water to Agricultural Practices and Natural Vegetation," on-going research, North Central Soil Conserv. Res. Lab, Minnesota, 1976.

continued . . .

Exhibit 1.3. (Continued)

Environmental Effects	Conclusions	Research Findings	References
		5. Over 97% of N and P lost from watersheds was associated with sediment loss, primarily in first 2 months after planting.	5. Burwell, R.E., and others, "Nutrient Transport in Surface Runoff as Influenced by Soil Cover and Seasonal Periods," Soil Sci. Soc. Amer. Proc., 1975.
Pollutant Changes in Media: Soil	Slight reductions to no change in erosion losses with this practice.		
Pollutant Changes in Media: Air	No Change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 1. Runoff and Erosion Control

Subtrend: 1.4 Narrow rows

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	0	1	small ↓ in sediment
Terrestrial	0	1	↓erosion; conserve topsoil
Human Health	0	0	No significant effect

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Use of narrow rows will have no significant ecological effect in 1985 and only minor beneficial aquatic and terrestrial effects in 2010. Decreased soil loss is the primary beneficial effect. Although herbicide and insecticide use could increase slightly, soil loss is also reduced slightly. Thus, overall pesticide residue concentration should not increase and there will be no significant human health effect.

(2) Research needs:

a. Feasibility of cotton and other row crops planted to narrower rows needs to be more fully researched.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 1.4. Environmental assessment of selected agricultural trends: Crop Production
Trend: 1. Runoff and Erosion Control
Subtrend: 1.4 Narrow Rows

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	This practice is currently applicable to corn and soybean production. Since 1973, 25% of the farm operators in one corn producing area have turned to narrow row corn. Extensiveness of use was estimated to be moderate in 1976 and expected to increase to major levels in 2010.	1. Workshop Evaluation Ratings--Panel 1: 1976 3, 1985 4, 2010 5.	1. Dev. Planning and Res. Assoc., Environmental Implications in Agriculture and Silviculture, 200 pp. 197.
Productivity	Overall productivity on a per acre basis will increase with narrow row crops. Increases of 10-20% have occurred with narrow row soybeans in field trails. However, the increase in yields that a farm operator will realize will depend on previous crop management practices, fertilizer use, the type of crop and climatic conditions.	3. Soybean yield increases up to 20% with narrow rows. Practice is recommended for use on soils with a soybean yield not normally above 40 bushels per acre. 4. Increased yields with soybeans in equidistant plantings.	3. "Solid-set soybeans can boost yield 20 percent," Crops and Soils 28(4): 22-23, 1976. 4. "Soybeans planted equidistantly increase yields," Crops and Soils, 29(3):26,1976.
Resource Use	More plants per acre will increase the total fertilizer requirement by 30-40% to meet the needs of the crop. Slight increases are expected in herbicide use but insecticide use will not change with this practice.	5. With narrow row corn, 96% of the farm operators increased nitrogen use by 33%.	5. Reference #2.
Pollutant Changes in Media: Surface Water	Narrow row crops will provide more cover for the land and will decrease soil losses slightly. Nutrient losses to surface water are not expected to decrease and could increase slightly since fertilizer use will increase (however, the number of plants utilizing fertilizer nutrients increases, so the potential for increased nutrient loss is small). There will be little or no effect on pesticide losses.	6. Decrease in row spacing provides more complete cover and tests show some reduction in erosion during first 2 months of crop year.	6. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency, Control of Water Pollution from Cropland, Volume I, Report No. ARS-H-5-1, Washington, D.C., 1975.
Pollutant Changes in Media: Ground Water	No significant changes.		
Pollutant Changes in Media: Soil	Slight reductions in erosion will occur with more ground cover.		
Pollutant Changes in Media: Air	No Change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 1. Runoff and Erosion Control

Subtrend: 1.5 Winter cover crops

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	0	1	regional areas, esp. S.E.
Terrestrial	0	1	↓erosion, conservation of topsoil
Human Health	0	-1	Paraquat use may ↑ →applicator hazards; ↑pesticide

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

There are no significant ecological effects in 1985. In 2010, minor beneficial aquatic and terrestrial effects result from small soil loss reductions. The south and southeast will benefit most from this practice. With the elimination of fall plowing, the need for winter cover crop is reduced. Paraquat use is expected to increase with winter cover crops and presents a human health danger by direct contact during application or through contact in field.

(2) Research needs:

a. Research on interseeding with winter cover crops is needed.

b. Research is needed on the increased use of paraquat, its effects, and alternatives to its use.

c. Development of farm implements for quicker, more efficient spring planting operations is needed.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 1.5. Environmental assessment of selected agricultural trends: Crop Production
Trend: 1. Runoff and Erosion Control
Subtrend: 1.5 Winter Cover Crops

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Extensiveness of this practice is minor in 1976 and will show a slight increase by 2010.	1. Evaluation Workshop Ratings-- Panel 1: 1976 1, 1985 2, 2010 2. Panel 2: 1976 1, 1985 1, 2010 1. In South more than 90% use winter cover crops.	1. Dev. Planning and Res. Assoc., Environmental Implications of Trends in Agriculture and Silviculture, 200 pp., 1977.
Productivity	Productivity values are variable. If winter cover crops are used as a second crop, total production will increase. However winter crops in some climates will reduce soil moisture and decrease spring crop yields.		
Resource Use	Fertilizer use could increase significantly (as much as 100 lbs. per acre) if winter cover crops are used as a second income crop. If crops are plowed under in the spring, then the fertilizer nutrients will simply be recycled and fertilizer use will not increase. Herbicide use may increase, especially if no-till planting follows in the spring. Insecticide use will not increase.		
Pollutant Changes in Media: Surface Water - Sediment	Winter cover crops will tend to reduce sediment losses slightly.	2. Winter cover crop reduced soil concentration in runoff by 18-58%.	2. Wishmeier, W., "Relation of Field Plot Runoff to Management and Physical Factors," Soil Sci. Soc. Am. Proc. 30(2):272-277, 1966.
Nutrients	Nutrient losses to surface water will decrease slightly if fertilizer use is not increased, but total yearly nutrient losses could increase if yearly fertilizer use is significantly increased.	3. No reduction in runoff with winter cover crop was found.	3. Mannering, J.V. and Burwell, R.E., "Tillage Methods to Reduce Runoff and Erosion in the Corn Belt," ARS Agr. Inf. Bulletin, #330, U.S.D.A., 1968.
Pesticides	No significant change is expected.		
Pollutant Changes in Media: Ground Water - Nutrients	N leaching decreases with this practice, however more fertilizer may be used, and overall loss by leaching would probably not be significantly decreased.	4. Winter cover of oats, timothy rye reduced N leaching 40-60%.	4. Frink, C.R., "The Nitrogen Cycle of a Dairy Farm," In: Relationship of Agriculture to Soil and Water Pollution, Cornell Univ., 1970.

continued . . .

Exhibit 1.5. (Continued)

Page 2

Environmental Effects	Conclusions	Research Findings	References
Pesticides	No significant change is expected. However, leaching of pesticides is not likely to represent a significant loss with normal application rates in most management practices.		
Pollutant Changes in Media: Soil	Erosion will be reduced slightly.	See research findings for sediment.	
Pollutant Changes in Media: Air	No change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 2. Conservation Tillage

Subtrend: 2.1 No-till

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic (Soil-Sediment)	+2	+3	↓sediment; low E; tend to ↑species diversity
Aquatic (Pesticide residues)	-1	-1	pesticide use ↑; pesticide concentrations could increase
Terrestrial	0	0	crop residues ↑; erosion; negative effect on non-target animals
Human Health	0	0	pesticide levels still within safety limits; no effect

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Aquatic and terrestrial effects are both beneficial and adverse. Aquatic systems will benefit from reduced turbidity and increased species diversity. However, pesticide residues in surface water could potentially be increased with no-till and create adverse effects in the aquatic ecosystem. Increased pesticide use can also have adverse effects on non-target terrestrial life. Retention of crop residues and reductions in erosion will be beneficial terrestrial effects. Human health effects will not be significant since pesticide residues in surface water should still be within safety limits even if they increase slightly with no-till.

(2) Research needs:

a. Further research and education is needed for the optimum use of fertilizer and pesticides with no-tillage practices.

b. The effect of increased pesticide use with no-till on pesticide losses to surface water should be determined.

c. Continued research is needed to develop and improve pesticides that are less toxic to non-target organisms.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 2.1 Environmental assessment of selected agricultural trends: Crop Production
Trend: 2. Conservation Tillage
Subtrend: 2.1 No-tillage

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Approximately 2.6% of all cropped land was no-till in 1977. While this practice is expected to increase to limited use in 2010, current projections (up to 55% of crops under no-till in 2010) seem high. Extensiveness may only be 10-20% in 2010.	1. Evaluation Workshop Ratings-- Panel 1: 1976 1 , 1985 1 , 2010 2 Panel 2: 1976 1 , 1985 1 , 2010 1 . 2. No-till is estimated at 7.9 million acres for 1977 (2.6%). 3. Percent of cropland zero tilled may reach 55% by 2010 (10% by 1985).	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, 200 pp., 1977. 2. "No-till Farmer," Milwaukee, Wisconsin, March, 1977. 3. U.S. Congress, "Alternative Futures for U.S. Agriculture," Committee Print, 94th Congress, 1st Session, Sept. 1975.
Productivity	Productivity can remain unchanged, increase by 10% or decrease by 12%. The type of crop, climate, and soil will dictate the productivity values. Multicropping practices will increase with no-till, resulting in increased productivity.	4. Yield reductions of 12% with no-till alone were found. 5. No significant decrease in productivity. 6. 10% increase in productivity on soils with good drainage. No increase on soils with poor drainage. 7. Both increased and decreased yields are shown for no till. 8. Yield response by no till is affected by crop properties, soils, climates, and pesticide effectiveness. Multicropping is enhanced by no till and could lead to production increases. Other land, maintained under permanent cover, can be brought into production.	4. Putman, J., Stipe, S., and McDivitt, J., A Summary of the Linear Programming Analysis for the Maumee Level B River Basin Study, preliminary working paper, 120 pp., 1977. 5. Johnson, H., Shrader, W.D., and Timmons, J. F., "Regional Development and Management of Land and Water Resources within Iowa," ongoing research, Agric. Exp. Station, Ames, Iowa, 1976. 6. "No-till is profitable on many soil types," Crops and Soils 27(9): 7-9, 1975. 7. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency, Control of Water Pollution from Cropland, Volume 1, Report No. ARS-H-5-1, Washington, D.C., 1975. 8. Reference #3.
Resource Use	Fertilizer and herbicide use increases by 15%, insecticide use by 11%. An estimated 5 million acres of land could be shifted to crop production with no-till and reduced till methods. Labor costs are reduced. More water will be conserved with no-till, as much as 2 inches per year.	9. Fertilizer and herbicide use increase 15%, insecticide use increases by 11%. 10. Fertilizer and herbicide use will increase. An estimated 5 million acres of land could be shifted to crop production with no till and reduced tillage. Labor will decrease.	9. Reference #4. 10. Reference #3.

Continued . . .

Exhibit 2.1. (Continued)

Page 2

Environmental Effects	Conclusions	Research Findings	References
		11. Increased N and pesticide requirements. Decreased labor.	11. Reference #7.
Pollutant Changes in Media: Surface Water - Sediment	Sediment reductions of 50-90% will result.	12. Sediment will be reduced by 58-69%.	12. Reference #4.
		13. Soil loss can be reduced an average of 50%. Individual studies with no till show soil losses reduced up to 98%.	13. Reference #3.
		14. Reductions up to 95% with no-till. Reductions will be less with increasing slopes and certain soils.	14. Reference #7.
Nutrients	While large soil loss reductions will tend to reduce nutrient losses, fertilizer use will increase by 15%. There will probably still tend to be reductions in total nutrient loss, but reduction will not be proportional to reductions in soil loss. N content of soil may also increase from weathering of crop residues.		
Pesticides	Effect of no till on pesticide losses is not well documented. Loss to surface water is greater when the compound is surface applied and not incorporated in the soil, and 11% more insecticides and 15% more herbicides will be used for no-till. While reductions of pesticides in surface water could occur, current research does not prove this. Increased use and surface application, even with reduced soil loss with no-till, could even cause slight increases in pesticide losses.	15. Transfer of pesticides into runoff water is greater when the compound is surface-applied than when it is incorporated.	15. Leonard, R.A., Bailey, G.W., and Swank, R.R., "Transport, Detoxification, Fate, and Effects of Pesticides in Soil and Water Environments," pp. 48-78. In: Land Application of Waste Materials, Soil Cons. Soc. Am., Iowa, 1976.
		16. The environmental effect of no-till and increased pesticide use is not known. No till will play an important part in reducing soil loss, but in contrast, laws and regulations relating to pesticide use could discourage further reductions in tillage.	16. Reference #3.
Pollutant Changes in Media: Ground Water	Nitrates in ground water will show no change to slight increases. Pesticide loss to ground water will not be significantly changed with no-till practices.		
Pollutant Changes in Media: Soil	Erosion losses will be decreased 50-90%.	See research finding on sediment.	

Continued . . .

Exhibit 2.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Residues	Crop residues will increase which may result in increased N loss to the soil or available for runoff. Additionally, residues may provide a hiding place for pests and increase the incidence of pests.		
Pollutant Changes in Media: Air	With some pesticides, increased volatilization will occur with surface applications. The vapor pressure, molecular weight, and other properties of a pesticide will determine the extent of vaporization.	17. Surface application subjects the pesticide to potential photodegradation, and a greater potential for volatilization.	17. Reference #15.

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 2. Conservation Tillage

Subtrend: 2.2 Reduced tillage

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic (Soil-sediment)	+2	+3	less effective than no-till, but higher E values
Aquatic (Pesticide residues)	-1	-1	potential for ↑ pesticides in water
Terrestrial	0	0	improved soil; ↑pesticide use on non-target organisms
Human Health	0	0	pesticide residue levels still within safety limits

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Reduced tillage (with crop residues remaining) is less effective than no-till in reducing soil loss, but extensiveness of reduced tillage will be greater. Therefore, the intensity of ecological effects are comparable for the two practices. Sediment reductions will reduce turbidity and increase species diversity. However, the potential for increased pesticide residues in surface water could have adverse effects on the aquatic ecosystem. Crop residues remaining on the soil and decreased soil loss are beneficieal to the terrestrial system, but increased pesticide use will have adverse effects on non-target organisms. Human health effects will not be significant.

(2) Research needs:

a. Research should determine the optimum amounts of residue to leave on surface and to incorporate into the soil with various climatic conditions, soils, and tillage practices.

b. Research is needed to determine the long term effect of conservation tillage on soil integrity.

c. The effect of increased pesticide use with reduced tillage on pesticide losses to surface water needs to be investigated.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 2.2. Environmental assessment of selected agricultural trends: Crop Production
Trend: 2. Conservation Tillage
Subtrend: 2.2 Reduced Tillage

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Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1977, an estimated 58.8 million acres (19% of total cropped acres) will be reduced tilled. An additional 40 million acres will be classified as less tilled. Less till includes chisel plowing, discing once instead of twice, and planting in rough ground. In 2010, a total of 40% of all cropland may be classified as reduced tilled.	1. Evaluation Workshop Ratings-- Panel 1: 1976 3 ; 1985 4 ; 2010 5 ; Panel 2: 1976 1 ; 1985 1 ; 2010 1 . 2. Reduced till will be used on 58.8 million acres in 1977. 3. In 2010, 55% of cropland may be no tilled and 40% reduced tilled.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume I, 200 pp., 1977. 2. "No-till Farmer", Milwaukee, Wisconsin, March 1977. 3. U.S. Congress, "Alternative Futures for U.S. Agriculture" and "Minimum Tillage," Committee Print 94th Congress, 1st Session, Sept. 1975.
Productivity	Productivity can remain unchanged, increase or decrease with reduced tillage. Multicropping practices will tend to increase with reduced till, causing increased productivity per acre. Not all crops or soil types are suited to reduced tillage.	4. With reduced till alone, production will decrease an average of 9.5%. With contour and reduced till together, yields will decrease an average of 16.5%. 5. Productivity with reduced till is variable with different crops and soils. Multicropping practices will increase with reduced till resulting in increased productivity for those acres. 6. Crop yields with reduced tillage are as good as, and sometimes higher than, those with plow-based systems.	4. Putman, J., Stipe, S., and McDivitt, J., A Summary of the Linear Programming Analysis for the Maumee Level B River Basin Study, preliminary working paper, 120 pp., 1977. 5. Reference #3. 6. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency, Control of Water Pollution From Cropland, Volume 1, Report No. ARS-H-5-1, Washington, D.C., 1975.
Resource Use	Fertilizer use will increase slightly. Herbicide use is up (0.6%) and insecticide use increases by 8.6%. An estimated 5 million acres of land will be shifted to crop production with reduced and no-tillage methods. Labor output will decrease. Energy to plant crops decrease, but increased energy will be used in manufacture of increased fertilizers and insecticides. Some soil moisture will be conserved with reduced tillage.	7. Fertilizer use decreases 5%, insecticide use increases by 8.6%, and herbicide use increases slightly, 0.5%. 8. Fertilizer use and pesticide use increase with reduced tillage methods. More land may be converted to agriculture with reduced and no-till practices (an estimated 5 million acres). 9. Fertilizer and pesticide use will increase.	7. Reference #4. 8. Reference #5. 9. Reference #6.

Continued . . .

Exhibit 2.2. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Surface Water Sediment	Sediment will be reduced an average of 14%. Reduced tillage is less effective than no-till in controlling soil loss.	10. Sediment will be reduced by 14%. 11. Conservation tillage is less effective than no-till in reducing soil loss.	10. Reference #4. 11. Reference #6.
Nutrients	There will probably be reductions in total nutrient loss to surface water, but reduction will not be proportional to reductions in soil loss (14%).		
Pesticides	Effect of reduced tillage on pesticide loss is not well documented. Loss to surface water is greater when a pesticide is surface applied and total pesticide use is 9% greater for reduced till. While reductions of pesticides in surface water could occur, there is not enough research data to support this.	12. Transfer of pesticides into runoff water is greater when compound is surface applied. More pesticide residues are lost in runoff water than in soil sediment loss. 13. The environmental effects of reduced tillage on pesticide residues is not known	12. Leonard, R.A., Bailey, G.W., and Swank, R.R., "Transport, detoxification, fate, and effects of pesticides in soil and water environments," pp. 48-78. In: Land Application of Waste Materials, Soil Cons. Soc. Am., Iowa, 1976. 13. Reference #3.
Pollutant Changes in Media: Ground Water	Nitrates in ground water will show no change to slight increases. Pesticide levels in ground water will not be significantly changed with reduced tillage.		
Pollutant Changes in Media: Soil	Erosion losses decrease an estimated 14%. Wind erosion losses will also decrease slightly. Crop residues increase, which lead to increased N available to the soil for leaching and runoff. Residues on soil also increase the incidence of pests.	See research findings on sediment.	
Pollutant Changes in Media: Air	Surface applications of some pesticides types leads to increased volatilization losses. The vapor pressure, molecular weight, and other chemical properties of a pesticide will determine the extent of vaporization.	14. Surface applications of pesticides subject the pesticide to a greater potential for volatilization.	14. Reference #12.

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 3. Improved Water Application

Subtrend: 3.1 Furrow basins

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	 2010	Factors/Rationale
Aquatic	-2	-3	return flow into surface water, ↑nutrients, ↑sediment, etc.
Terrestrial	-2	-3	↑salinity build-up in soil
Human Health	-1	-1	↓in drinking water quality; potential for ↑nitrates

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Furrow basins may be the least efficient method of irrigation. Nutrients, sediment, pesticide residues in surface water tend to be greater for this irrigation method. For these reasons, aquatic, terrestrial and human health effects were judged adverse. (If return flow is controlled, Subtrend 3.4, then aquatic effects would be 0.) Human health effects result from decreased quality of drinking water, and potential increases in nitrates.

(2) Research needs:

a. The effects of salinity on human health and on animal populations needs further investigation.

b. Investigation of irrigation methods and quality of return flows is needed.

c. The feasibility of water renovation through filtering and desalting should be determined.

d. The feasibility of diverting return flows to wildlife preserves or other productive use should be investigated.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 3.1. Environmental assessment of selected agricultural trends: Crop Production
Trend: 3. Improved Water Application
Subtrend: 3.1 Furrow Basins

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Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1969, 50% of irrigated cropland used furrow basins. Extensiveness in 1976 is not known. Evaluation workshop ratings indicate that significant improvement is not likely to occur with improved furrow basin management.	1. Evaluation Workshop Ratings-- Panel 2: 1976 _1_; 1985 _0_; 2010 _0_. (Reflects improvement with use of furrow basins). 2. In 1969, 19.2 million acres (50% of all irrigated crops) were irrigated by furrow basins.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume I, 200 pp., 1977. 2. U.S. Bureau of Census, Census of Agriculture, 1969, Volume 5, Special Reports, Part 15, Graphic Summary, 1971.
Productivity	Yields from irrigated croplands are higher than U.S. average yields. Research data showing specific yield increases contributed by furrow basin irrigation is not available.	3. Yield from irrigated cropland is 11% higher in the East and 32% higher in the West than U.S. averages.	3. Reference #2.
Resource Use	Fertilizer, herbicide, and insecticide use remain unchanged. Water use for furrow irrigation is 2.06 acre feet of water per acre. Efficiency of furrow basin irrigation is 35%.	4. Furrow basin use 2.06 acre feet of water per acre. 5. Efficiency of furrow basin irrigation is 35%, less than that of sprinkler or drip irrigations.	4. Reference #2. 5. Jensen, M.E., Scientific Irrigation Scheduling for Salinity Control of Irrigation Return Flows, U.S. Environmental Protection Agency, 1975.
Pollutant Changes in Media: Surface Water--Sediment - Nutrients - Pesticides	Certain practices must be used with furrow basins to reduce sediment and associated sediment materials (nutrients, pesticides). These practices are as follows: 1. Use only on flat or very gentle slopes; 2. Soil should have low infiltration rates; 3. Land grading is essential; 4. Apply water at slower rates to reduce erosion, water logging, and improve efficiency. 5. Furrow stream flow should be minimal; 6. Use of benching, diagonal, or contour furrows will reduce erosion; 7. Slopes of furrows should be very gentle; 8. Lining of furrow drops with concrete flumes or other material reduce soil loss. 9. Irrigations should be scheduled.	6. Landgrading is essential for furrow irrigation. To avoid excessive erosion in irrigating with furrows, the slope of the furrows should not exceed 2%. Contour and benched furrows reduce erosion potential. Concrete-lined ditches, or concrete or metal flumes should be used for conveying water down slopes to recess sediment losses. 7. Furrows should be used on fairly flat land with soil that has low infiltration rates. Application rates should not be too rapid and minimal furrow stream flow should be practiced. 8. Current irrigation practices are not efficiency. Efficiency increases with scheduling, rate of application, and amount of water applied. With furrow basins, it is difficult to measure amount of water applied.	6. Booker, L.J., Surface Irrigation, FAO, Italy, 1974. 7. Jenke, A.L., Evaluation of Salinity Created by Irrigation Return Flows, U.S. Environmental Protection Agency, 127 pp., 1974. 8. Jensen, M.E., Scientific Irrigation Scheduling for Salinity Control of Irrigation Return Flows, U.S. Environmental Protection Agency, 91 pp., 1975.

Continued . . .

Exhibit 3.1. (Continued)

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Environmental Effects	Conclusions	Research Findings	References
	These practices for furrow basins will reduce sediment loss and associated nutrient losses greatly in some areas. However with some lands, it is virtually impossible to reduce sediment in furrow irrigation to the extent sediments and other suspended solids in return flow will meet water quality standards. In general, sediment and associated losses are greater for furrow basins than sprinkler or subsurface irrigations.	9. Although sediment yields can be reduced in the Yahima Valley with improved soil and water application methods, it is still virtually impossible to reduce erosion in the furrow irrigation system to the extent that sediment and related contaminants in return flows will meet water quality standards for that region.	9. Carlile, B.L., "Sediment Control in Yahima Valley." In: Managing Irrigated Agriculture to Improve Water Quality, Proc. of National Conf. on Managing Irrigated Agriculture to Improve Water Quality, Colorado State Univ., 1972.
Pollutant Changes in Media: Ground Water	Reductions in ground water and associated pollutants can be obtained with furrow basins. However, these reductions are associated with the management practices listed above. If these practices are followed, ground water pollution from furrow irrigation will be comparable to other irrigation methods. However, research data shows they are not routinely followed, and considerable ground water pollution does occur. Improved furrow irrigation will not significantly reduce ground water pollutants without scheduling, and improved irrigation facilities.	10. The most abused practice in irrigation is excessive water applications and tends to be more serious with furrow irrigation that sprinkler irrigation scheduling also reduces potential ground water pollution, but it is not routinely practiced. (See 3.5 Irrigation Scheduling for Potential Benefits.)	10. References #7 and #8.
Pollutant Changes in Media: Soil	Salinity tends to be greater for furrow irrigation compared to sprinkler irrigation.	11. Salinity is greater for furrow irrigation compared to sprinkler irrigation. 12. Increased spot salinity occurs with furrow basins, because of low spots and high spots in the land. Soluble salts tend to concentrate in the surface and center of beds causing decreased yields.	11. Salinity in Water Resources, Proc. of the 15th Annual Western Resources Conference at the Univ. of Colorado, Merriam, publishers, 1974. 12. Reference #6.
Pollutant Changes in Media: Air	No Change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 3. Improved Water Application

Subtrend: 3.2 Land grading

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	-1	-1	land grading + furrow basins = ↓pollutants
Terrestrial	-1	-1	due to salinity
Human Health	0	-1	long term effect from ↑ nitrate concentration

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Land grading will be used with furrow basins, thus pollutants from furrow basins will decrease in intensity. Salt accumulation will be less when land grading is used with furrow basins. There is still a long-term effect of nitrate concentrations increasing in surface waters even with land grading with furrow basins.

(2) Research needs:

a. The effects of salinity on human health and on animal populations needs further investigation.

b. Investigation of irrigation methods and quality of return flows is needed.

c. The feasibility of water renovation through filtering and desalting should be determined.

d. The feasibility of diverting return flows to wildlife preserves or other productive use should be investigated.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 3.2. Environmental assessment of selected agricultural trends: Crop Production
Trend: 3. Improved Water Application
Subtrend: 3.2 Land Grading (analyzed as an irrigation practice only)

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Land grading is important in irrigated crop production and will increase in use by 2010. Actual extensiveness in irrigated crop production is unknown.	1. Evaluation Workshop Ratings-- Panel 2: 1976 4 ; 1985 5 ; 2010 5 .	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977.
Productivity	Productivity will increase with the use of land grading. The increase will depend on the crop, soil, irrigation practices, and other crop management practices.	2. Land grading tends to reduce concentrated areas of salinity seeps and increase crop yields. 3. Waterlogging of land decreases with land grading and increases land productivity.	2. Booker, L.G., Surface Irrigation, FAO, 1974. 3. Jenke, A.L. Evaluation of Salinity Created by Irrigation Return Flows, U.S. Environmental Protection Agency, 127 pp., 1974.
Resource Use	Total irrigation water in furrow basins can be reduced up to 40% with land grading and water measuring devices. Reduction of total water applied will reduce the soluble fertilizer requirement. Pesticide requirement will remain unchanged to a slight decrease. Energy and labor requirement increase with land grading.	4. Reductions up to 40-50% in water use may occur following leveling and the installation of simple water measuring devices. Decreased water use will decrease soluble fertilizer requirements. 5. Labor requirement for furrow irrigation is greater with land grading and other management practices.	4. Reference #3. 5. Reference #2.
Pollutant Changes in Media: Surface Water--Sediment - Nutrients - Pesticides	Elimination of excessive water application in irrigation causes decreases in soil erosion, nutrient and pesticide losses.	6. Excessive water in irrigation increases sediment losses. 7. Land grading decreases soil losses.	6. Reference #3. 7. Reference # 2.
Pollutant Changes in Media: Ground Water	Slight reductions in ground water and associated pollutants will occur with land grading.		
Pollutant Changes in Media: Soil	Concentrated salinity areas, resulting from high and low spots in irrigated land are reduced.	8. Soluble salts tend to concentrate in the surface and center of beds (irrigation). Landing grading levels the land and reduces spot salinity.	8. Reference #2.
Pollutant Changes in Media: Air	No Change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 3. Improved Water Application

Subtrend: 3.3 Sprinklers

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	-1	-2	↓ground water supply (regional)
Terrestrial	-1	-1	↓wildlife habitat; ↑soil salinity
Human Health	0	0	potential for ↑ nitrates is less

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Aquatic and terrestrial effects are adverse with sprinkler irrigation. Groundwater supplies can and are seriously reduced with sprinkler systems. Surface water pollution will still occur with sprinklers, but will be less for sprinklers than for furrow basins. Soil salinity will continue with sprinklers, and wildlife habitat is destroyed with sprinkler system installation (fence rows are taken out). The potential for increased nitrate concentrations in ground water is less with this practice, so human health effects will not be significant.

(2) Research needs:

a. The use of effluents in sprinkler irrigation should be investigated.

b. Research on efficient irrigation practices should include investigation of ground water depletions.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 3.3. Environmental assessment of selected agricultural trends: Crop Production
Trend: 3. Imrpoved Water Application
Subtrend: 3.3 Sprinklers

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1969, 7.2 million acres (18.8% of all irrigated cropland) used sprinkler irrigation. Extensiveness in 1976 is not known, but estimated to have increased since 1969.	1. Evaluation Workshop Ratings-- Panel 2: 1976 1 ; 1985 2 ; 2010 2 . 2. Sprinkler irrigation was used on 7.2 million acres in 1969.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, 200 pp., 1977. 2. U.S. Bureau of Census, Census of Agriculture, 1969, Volume 5, Special Reports, Part 15, Graphic Summary, 1971.
Productivity	Yields from irrigated cropland are higher than U.S. average yields. Use of highly saline water in sprinklers can leave toxic, often lethal salt deposits on leaves and cause sprinklers to clog. Additionally, some crops subject to fungi are aggravated by high-moisture conditions with sprinkler irrigation. These conditions will reduce yields.	3. Yield from irrigated cropland is 11% higher in the East and 32% higher in the West than U.S. average. 4. Highly saline waters can leave toxic deposits on leaves. High moisture conditions of sprinkler irrigation can aggrevate diseases as fungi in some crops.	3. Reference #2. 4. Jenke, A.L., Evaluation of Salinity Created by Irrigation Return Flows, U.S. Environmental Protection Agency, 127 pp., 1974.
Resource Use	Fertilizer, herbicides, and insecticide use remain constant. Sprinkler irrigation uses 1.39 acre feet of water per acre, considerably less than furrow irrigation. Drip irrigation (0.5% of all irrigated acres in 1980) is even more efficient than sprinkler irrigation. Efficiency with sprinklers range from 49-58% efficiency. Initial costs and energy requirements are higher for sprinkler than furrow methods.	5. Sprinkler irrigation uses 1.39 acre feet of water per acre. 6. Sprinkler efficiency in twelve events ranged from 49-58% efficiency. Drip irrigation is the most efficient irrigation method but only 0.5% of all irrigated acres will use this practice in 1980.	5. Reference #2. 6. Jensen, M. E., Scientific Irrigation Scheduling for Salinity Control of Irrigation Return Flows, U.S. Environmental Protection Agency, 91 pp., 1975.
Pollutant Changes in Media: Surface Water--Sediment - Nutrients - Pesticides	Potential soil loss and associated pollutants can be reduced with sprinkler irrigation if certain practices are used. These practices are as follows: 1. Use on soils with high infiltration rates. It can be used on sloping lands with rough and thin soils. 2. Application rate should be slow. 3. Know the amount of irrigation water applied. 4. Use irrigation scheduling for maximum efficiency and to reduce potential soil loss. 5. Do not irrigate with sprinkler on very windy days.	7. Slow application of water by sprinkler methods reduce erosion. Sprinkler can be used on soils with high water uptake, on sloping lands, and on rough, thin soils. Irrigation scheduling will improve sprinkler efficiency and reduce erosion potential and surface runoff. 8. Sprinkler systems tend to reduce excessive water applications, thus reducing runoff potential. It is easier to measure amount of water applied by sprinkler methods.	7. Reference #4. 8. Reference #6.

Continued . . .

Exhibit 3.3. (Continued)

Environmental Effects	Conclusions	Research Findings	References
	In general surface runoff, soil loss and associated pollutants are less for sprinkler irrigation compared to furrow.		
Pollutant Changes in Media: Ground Water	While ground water pollutants tend to be less with sprinkler irrigation compared to furrow, potential pollutants can be further reduced with irrigation scheduling, and other efficiency practices (See 3.5 Irrigation scheduling for details). Sprinkler irrigation cannot be relied upon to significantly reduce ground pollutants without these practices.	9. Traditional methods to improve irrigation management will not result in further changes in irrigation management unless water costs increase substantially. Over the past 20 years, irrigation efficiency has not increased. Improvement of salinity problems, and ground water problems will depend upon irrigation scheduling and improved irrigation facilities.	9. Reference # 6.
Pollutant Changes in Media: Soil	Salinity tends to be slightly less for sprinkler irrigation compared to furrow. However, each year productive agriculture land is lost to salinity regardless of irrigation method.	10. Salinity is less for sprinkler irrigation compared to furrow irrigation. 11. Each year productive agriculture land is lost to salinity. Crop production is reduced on one-quarter of the irrigated acreage in Western U.S.	10. Salinity in Water Resources, Proc. of the 15th Annual Western Resources Conf. at the Univ. of Colo. Merriam publishers, 1974. 11. Law, J.P., and others, "The need for implementing irrigation return flow quality control." In: Managing Irrigated Agriculture to Improve Water Quality, Proc. of the Nat. Conf. on Managing Irrigated Agriculture to Improve Water Quality, 1972.
Pollutant Changes in Media: Air	No significant changes will result. On windy days, water loss can occur, but will not adversely affect the air.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 3. Improved Water Application

Subtrend: 3.4 Recycling & controlling tailwater

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+2	+3	↓water requirements; ↓pollutants in water
Terrestrial	-1	-1	disposal of tailwater pollutants; soil salinity not affected
Human Health	+1	+1	assumes proper processing, further water degradation will not occur

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Aquatic effects will be beneficial with control of tailwater. Irrigation water requirements will be reduced and pollutants in surface water will be decreased. Terrestrial effects are adverse since soil salinity will not be significantly affected with this practice, and terrestrial pollutants may potentially be increased with the disposal of tailwater pollutants. Minor beneficial human health effects will result with proper processing of tailwater.

(2) Research needs:

a. Continued research is needed on the proper treatment of tailwater and on the disposal of tailwater and subsurface drainage wastes.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 3.4. Environmental assessment of selected agricultural trends: Crop Production
Trend: 3. Improved Water Application
Subtrend: 3.4 Recycling and Controlling Tailwater

Page 1

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Extensiveness in 1976 is not known. However, based on workshop rating, this practice will increase to important levels by 2010. Control of the total irrigation return flow (surface tailwater and subsurface drainage waters) will be considered in this subtrend.	1. Evaluation Workshop Rating-- Panel 2: 1976 _2_; 1985 _3_; 2010 _4_.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977.
Productivity	Tailwater will have increased concentrations of sediment, nutrients, and pesticides; however, productivity will not be significantly changed with proper treatment of recycled tailwater.	2. Concentration of salt, and NO_3-N is greatly increased in tailwater. However, at times the chemical quality of subsurface drainage water is better than that of the irrigation water diverted at further points down river for irrigation.	2. Carter, D.L., "Irrigation return flows in southern Idaho," pp. 47-53. In: Managing Irrigated Agriculture to Improve Water Quality, Proc. of Nat. Conf. on Managing Irrigated Agriculture to Improve Water Quality, 1972.
		3. Concentration of salts and nutrients is several times greater in ground water than in initial irrigation water.	3. Jenke, A.L., Evaluation of Salinity Created by Irrigation Return Flows, U.S. Environmental Protection Agency, 127 pp., 1974.
		4. Concentration of salts in return flow can be greatly increased.	4. Salinity in Water Resources, Proc. of the 15th Annual Western Resources Conf. at the Univ. of Colorado, Merriman publishers, 1973.
Resource Use	Fertilizer, insecticide, and herbicide use remains constant. Water use can be decreased as much as 30% with reuse of return flows in irrigation.	5. About 35% of applied irrigation water is return flow.	5. Reference #3.
		6. 50% of total input water becomes subsurface drainage water.	6. Reference #2.
Pollutant Changes in Media: Surface Water--Sediment - Nutrients - Pesticides	Sediment, and associated nutrients will be trapped if surface water is collected. This reduces sediment and pollutant loadings of rivers if the water is not returned to the rivers. Surface runoff water quality will have increased sediment, but salt concentration does not differ from initial irrigation water.	7. Surface runoff quality did not differ from that of the irrigation water except for sediment concentration.	7. Reference #2.
		8. Nutrients, pesticides, sediment, and salts will be confined to the field by control of tailwater.	8. Reference # 3.
Pollutant Changes in Media: Ground Water	Control of ground water can significantly decrease the pollutant loadings of a river. The ground water will have high salt concentrations. Before this water can be	9. Subsurface drainage water should be treated, diluted, or diverted to sinks, and settling basins before reuse.	9. Reference #3.

Continued . . .

Exhibit 3.4. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Ground Water (Continued)	diverted back to the river or to agriculture, it should be diluted with large amounts of incoming water, or diverted to sinks or settling basins. This will reduce sediment and salt concentrations to reasonable limits.	10. Recovered drainage waters can readily be returned to the irrigation supply after settling, treatment for pollutant removal, or diluted to minimize the detrimental effects.	10. Law, J.P. and others, "The need for implementing irrigation return flow quality control," pp. 1-17. In: Managing Irrigated Agriculture to Improve Water Quality, Proc. of Nat. Conf. on Managing Irrigated Agriculture to Improve Water Quality, 1972.
Pollutant Changes in Media: Soil	Soil salinity will not be affected by recycling and controlling tailwater.		
Pollutant Changes in Media: Air	No Change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 3. Improved Water Application

Subtrend: 3.5 Irrigation scheduling and efficiency

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+1	+1	↓water use; ↓pollutants
Terrestrial	0	+1	small ↓ soil salinity
Human Health	0	0	

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Aquatic effects will be beneficial in 1985 and 2010 from reductions in water use, and small reductions in surface water pollutants. Minor beneficial terrestrial effects may result in 2010 with samll decreases in soil salinity. Human health will not be significantly affected with this practice.

(2) Research needs:

a. Continued research is needed on irrigation scheduling and other irrigation efficiency practices.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 3.5. Environmental assessment of selected agricultural trends: Crop Production
Trend: 3. Improved Water Application
Subtrend: 3.5 Irrigation Scheduling and Efficiency

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1974, less than 1% of all irrigated cropland had professional irrigation scheduling. Irrigation scheduling will increase greatly by 2010.	1. Evaluation Workshop Ratings-- Panel 2: 1976 _3_; 1985 _4_; 2010 _5_. 2. 382,000 acres of irrigated cropland used some professional irrigation scheduling in 1974.	1. Dev. Planning & Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, 200 pp., 1977. 2. Jensen, M.E., Scientific Irrigation Scheduling for Salinity Control of Irrigation Return Flows, U.S. Environmental Protection Agency, 91 pp., 1975.
Productivity	Scheduling can increase crop yields significantly.	3. Major benefits to the farm operator with irrigation scheduling would be improved crop yields and quality. 4. Crop yields are expected to increase with irrigation scheduling.	3. Reference #2. 4. Jenke, A. L., Evaluation of Salinity Created by Irrigation Return Flows, U.S. Environmental Protection Agency, 127 pp., 1974.
Resource Use	Fertilizer use would decrease with irrigation scheduling. Herbicide and insecticide use will remain constant. Water use will decrease 10% with scheduling and up to an additional 20% with lining of irrigation conveyance ditches.	5. Irrigation efficiencies will improve an average of 10% with scheduling. 6. Proper irrigation scheduling could increase water efficiency 10-15%. Estimated water losses by canal seepage range from 13-48% with an estimated average of 20%. 7. Lining on canals reduce seepage losses from 5-10% of total water to 1-2%. Research data shows excessive irrigation by many farmers.	5. Reference #2. 6. Reference #4. 7. Skogerboe, G.V. and Walker, W.R., "Salinity control measures in the Grand Valley," pp. 123-136. In: Managing Irrigated Agriculture to Improve Water Quality, Proc. of Nat. Conf. on Managing Irrigated Agric. to Improve Water Quality, 1972.
Pollutant Changes in Media: Surface Water--Sediment - Nutrients - Pesticides	Surface runoff will decrease causing decreases in sediment and associated nutrients. With some soils and irrigation techniques, reductions can be significant. Salt concentration in surface runoff is comparable to original irrigation water. Thus, no reductions will result for salts.		

Continued . . .

Exhibit 3.5. (Continued)

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Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Ground Water	Salt concentrations in ground water can be reduced significantly if conveyance losses are eliminated. With irrigation systems that allow even application, scheduling can reduce salt loads in the return flow. Other irrigation systems may not show a decrease of salts in the return flow.	8. Salt concentrations in return flows can be reduced with lining of conveyance canals. 9. Salt concentrations in return flows may or may not be reduced significantly, depending on type of irrigation system and soil type. Improved irrigation facilities are needed with scheduling in some areas.	8. Reference #7. 9. Reference #2.
Pollutant Changes in Media: Soil	Soil salinity decreases with irrigation scheduling. Water use for leaching of salts is included in scheduling. Application rates and leaching times are scheduled for maximum salt leaching.	10. Irrigation efficiency includes water for leaching to control soil salinity. Leaching and application rates are scheduled for maximum efficiency. With more frequent applications, salt concentrations are not as likely to build up to dangerous levels in the soil.	10. Reference #2, Reference #4.
Pollutant Changes in Media: Air	No Change.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 4. Improvement of Seeds and Plants

Subtrend: 4.1 Weather resistance

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	0	0	
Terrestrial	0	0	
Human Health	0	0	

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

The effect is not expected to be significant on any of the ecosystems. Some marginal land will be brought into production; on the other hand, multicropping can be expected to increase slightly. These will tend to cancel each other out in the overall impact on runoff.

(2) Research needs:

a. Research involving these improvements should include investigation of environmental impacts.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 4.1. Environmental assessment of selected agricultural trends: Crop Production
Trend: 4. Improvement of Seeds and Plants
Subtrend: 4.1 Weather resistance

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Gradual improvements are being made with weather resistance in crops, but no major developments are expected for the next decade, at least. Research is on-going, but hampered by lack of additional research money.	1. Evaluation Workshop ratings Panel 1: 1976 4 ; 1985 4 ; 2010 5 Panel 2: 1976 1 ; 1985 1 ; 2010 1 2. Research for weather resistant crops continues. Progress has been made, but no major developments are expected for another decade.	1. Dev. Planning and Research Assoc., Implications of Trends in Agriculture and Silviculture, Vol. 1, 200, pages, 1977. 2. National Academy of Sciences, Climate and Food, Washington, D.C., 1976
Productivity	Productivity could be greatly increased with weather resistance. Plants that can withstand severe drought or prolonged cold periods would provide the farmer with multicropping opportunitites with sustained yields. Short-growing season plants could be used for climates that currently have summers too short for crops.	3. High yielding, short-season soybeans that could grow further north increased Minnesotas soybean production from 2% to 8% of U.S. total. In 1975, drought tolerant corn hybrids, maintained yields during severe drought. Semidwarf wheat has improved water efficiency which maintains yields under stress. 4. Potential productivity will increase greatly with development of climate resistant crops.	3. Reference #2 4. National Academy of Sciences - World Food and Nutrition Study, Wash.,D.C., 1975.
Resource Use	Until commercial use of weather resistance crops increases, there will be no increase in resource use. By 2010 however, fertilizer and pesticide use could increase 50% or more, with year round cropping. It is doubtful at this time if year round cropping will occur in most areas. Rather crops will be developed for normal cropping season which are more resistant to weather stresses. More land in unfavorable climates could be brought into agriculture production by 2010		
Pollutant changes in Media	Pollutant changes are difficult to evaluate. With single cropping, there will be no change. Should multicropping increase significantly by 2010, pollutants would also increase significantly.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 4. Improvement of Seeds and Plants

Subtrend: 4.2 Salt resistance

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	0	-1	Disruption of brackish coastline
Terrestrial	0	-1	Loss of habitats on saline soils
Human Health	0	0	

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

No significant effects are expected by 1985. Adverse effects of a minor nature can be anticipated on the aquatic and terrestrial systems by 2010. Ths use of salt resistance plants and seed will permit cropping on the brackish coastline. The resulting drainage will affect the brackish waters. Returning saline land to production will reduce.

(2) Research needs:

a. Environmental implications should be made a part of ongoing research in this area.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 4.2. Environmental assessment of selected agricultural trends: Crop Production
Trend: 4. Improvement of Seeds and Plants
Subtrend: 4.2 Salt resistance

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Current research data shows progress in breeding plants that are resistant to high concentrations of salt and that these plants will be used commercially in the future. Widespread commercial use is still several years away.	1. Evaluation workshop ratings Panel 1: 1976 1 ; 1985 1 ; 2010 1 . Panel 2: 1976 3 ; 1985 4 ; 2010 5 .	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Vol. I, 200 pages, 1977.
		2. Research with salt resistant strains of barley is promising.	2. "Salt tolerant plants sought," Crops and Soils,27(7) 19-20, 1975.
		3. Crop production based on seawater or other saline sources is an attainable goal.	3. Rush, D.W., Norlyn, J.D., and Epstein, E. "Salt-resistant crops coming," Crops and Soils, 29(3): 7-9, 1976.
Productivity	Productivity in saline areas would increase, especially where salinity build-up reduces crop yields or has taken land out of agriculture production. Currently technology is developing salt resistant crops but yield results show that these crops are not feasible for commercial use at this time.	4. First year trials of salt-resistant barley crops grown under very unfavorable conditions were 21% of yield from irrigated barley. Research people found these results very encouraging.	4. Reference #3
Resource Use	Fertilizer and pesticide use would remain constant. Increased land could be brought into production in highly saline areas.		
Pollutant Change in Media	No change		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 4. Improvement of Seeds and Plants

Subtrend: 4.3 Production efficiency

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	0	-1	Increased fertilizer use
Terrestrial	0	0	Assumes no increase in land cropped
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

No significant effects are expected by 1985. Increased fertilizer requirements can expect to have adverse effects of a minor nature on the aquatic system by 2010.

(2) Research needs:

a. Environmental implications should be made a part of ongoing research in this area.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 4.3. Environmental assessment of selected agricultural trends: Crop Production
Trend: 4. Improvement of Seeds and Plants
Subtrend: 4.3 Production efficiency

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Substantial improvements in agricultural production efficiency have been made during the past two decades. While research will continue to improve production efficiency, it is doubtful if comparable advances can be obtained from such technology improvements in the short-run future. Further significant yield increases will require greater photosynthetic efficiency. Research continues on photosynthesis process in plants. Factors that control photosynthesis are not well understood and until these factors are found, progress in production efficiency will be slow.	1. Evaluation Workshop Ratings Panel 1: 1976 _4_; 1985 _4_; 2010 _5_. Panel 2: 1976 _1_; 1985 _1_; 2010 _2_.	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1977.
		2. Great gains have been obtained with crop production efficiency in last decades. It is doubtful if comparable advances can be obtained from technology improvements in the short-term future.	2. National Academy of Sciences, Agricultural Production Efficiency, Washington, D. C., 1975.
		3. Impressive yield increases in agriculture in past 25 years came from a combination of new varieties, high rates of fertilization, high plant populations, disease resistance, and control of insects and weeds. Further significant yield increases will require photosynthetic efficiency control.	3. National Academy of Sciences. World Food and Nutrition Study, Washington, D.C., 1975.
Productivity	Further productivity increases will be the result of biochemical or genetic control of plants photosynthesis process. Yields and enhanced crop quality will result from improved production efficiency.	4. Control of photosynthesis in plants is the key to increased yields and food quality.	4. Reference #3
Pollutant Changes in Media	No change		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 4. Improvement of Seeds and Plants

Subtrend: 4.4 Disease, insect, and nematode resistant crops

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+2	+4	Decrease in pesticide use
Terrestrial	+1	+3	-----
Human Health	+1	+2	Less injuries associated with application

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Beneficial effects are expected to stem primarily from the decrease in pesticide use. The greatest benefits are expected to occur in the aquatic systems with less pesticide runoff in surface waters. The reduction in pesticide use would reduce the likelihood of injuries associated with application and reentry.

(2) Research needs:

a. Ongoing research should include investigations of the environmental impacts.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 4.4. Environmental assessment of selected agricultural trends: Crop Production
Trend: 4. Improvement of Seeds and Plants
Subtrend: 4.4 Disease, insect, and nematode resistant crops

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Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Approximately 75% of all cropland is planted with seed varieties that show resistance to some disease or insect. Research continues to develop more resistant crops to replace these with even more resistant varieties. By 2010, some crops will be very resistant to certain diseases and pests.	1. Evaluation Workshop Ratings Panel 1: 1976 4 ; 1985 4 ; 2010 5 .	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1977.
		2. Seventy-five percent of U.S. cropland utilities resistant varieties (insect) developed during past 50 years. Research continues with almost all crop varieties to find or improve resistance to insects.	2. National Academy of Sciences, Contemporary Pest Control Practices and Prospects, Volume I, Washington, D. C., 1975.
Productivity	Productivity can increase substantially with crops having inbred resistant to disease and insects.	3. Under greenbug attack, a new sorghum variety had yields up to seven times higher than susceptible sorghum varieties. Seeds will be available in 1977 or 1978.	3. "23 new sorghum breeding lines from Texas," Crops and Soils 29(7): 23, 1977.
		4. Current research with corn strains resistant to the corn borer looks very promising.	4. Pardee, W. D., and Gracen, V. E., "Crops fight back, bred-in insect resistance," Crops and Soils 28(7): 8-9, 1976.
		5. A new millet variety is resistant to leaf spot disease and has 7-20% more foliage than other millet varieties. Yields were higher for a variety of alfalfa resistant to stem nematodes, downy mildew, and bacterial wilt.	5. "Varieties," Crops and Soils 28(7): 23,1976.
		6. Disease resistant crops have lead to increased crop yields.	6. National Academy of Sciences, World Food and Nutrition Study, Washington, D. C., 1975.
Resource Use	Fertilizer and herbicide use remains unchanged. Insecticide use will decrease as more insect disease resistant crop varieties are developed. Crop resistance is generally insufficient to control insects and supplemental chemicals may have to be used, but fewer treatments are needed. There are some exceptions where crops are entirely resistant to insects. Pesticide cost would be reduced.	7. Supplemental applications of chemicals may need to be used with insect resistant crops, but fewer treatments are needed. Some crops seen to be entirely disease resistant and do not require supplemental chemical pesticide applications.	7. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency, Control of Water Pollution from Cropland, Vol. 1, Report No.ARS. H-5-1, Washington, D.C., 1975.

Continued . . .

Exhibit 4.4. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media	Pesticide residues in water, soil, and air will be reduced as more insect resistance crops are developed. Decrease will be gradual since, development of these crops will be slowly evolving. By 2010, there could be substantial reductions in pesticide residues in the environment. Soil and nutrient losses will tend to remain unchanged. If widespread yield increases occur, over the crop yields now obtained with chemical pesticides, soil loss and nutrient loss will decrease. This decrease is a result of high yielding crops reducing surface run-off and ground water losses.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 5. Scouting and Integrated Controls

Subtrend: 5.1 & 5.2 Scouting-surface & remote sensing scouting

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+1	+3	Reduced pesticide use
Terrestrial	+1	+3	Reduced pesticide use
Human Health	0	+1	Reduced reentry problems

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Beneficial effects are expected to stem primarily from reductions in pesticide use. The effects would be only minor in 1985. By 2010, significant effects would occur in the aquatic and terrestrial systems.

(2) Research needs:

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 5.1 & 5.2. Environmental assessment of selected agricultural trends: Crop Production
Trend: 5. Scouting and Integrated Controls
Subtrends: 5.1 & 5.2. Scouting-surface and remote sensing scouting

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Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Use of scouting to identify specific insect pests areas and predict which crop areas need chemical treatment is very limited in 1976. Diagnostic and predictive methods are not currently reliable for pest control. By the time an area has been identified as having a potential pest problem, damage has often, already occurred. Much research and public education is needed before this practice will become a potential method to reduce chemical pesticides.	1. Evaluation Workshop Ratings Surface scouting Panel 1: 1976 1 ; 1985 3 ; 2010 5 . Remote sensing scouting Panel 1: 1976 1 ; 1985 1 ; 2010 2 .	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1977.
		2. With present state of art, it is impossible to identify and predict which field or area may or may not be damaged by insects. Often fields cannot be selected until insect damage has already occurred. Currently pilot scouting programs exist in Iowa and Illinois, which may prove successful.	2. U.S. Environmental Protection Agency, Farmers Pesticide Use Decisions and Attitudes on Alternation Crop Protection Methods, 158 pages, 1974.
		3. Farmers often appear to be unable or unwilling to base their pest control decisions on complex calculations of the relationships between pest infestations, yield losses, and pesticide applications. They adopt pest control program that tend to require regular and heavy use of pesticides. Considerable research is needed to accurately predict pesticide losses.	3. National Academy of Sciences, Volume 1, Contemporary Pest Control Practices and Prospects, Wash., D.C. 1975.
Productivity	Very limited research exists for the success of scouting programs to successfully predict which areas need to be treated with pesticides. Areas can show sustained crop yields without use of pesticides. Pilot scouting programs made surveys for several insects, found these to be economic thresholds, and no control was recommended or applied. Crop yields are assumed to be comparable to treated areas. Sometimes damage has already occurred by the time a pest problem is identified, leading to decreased yields. Some yield increases have been attributed to decreased use of hydrocarbon pesticides.	4. Pilot scouting programs determined insect levels to be below the economic threshold, and no control was recommended or applied. Acres with decreased hydrocarbon use since 1966 have shown increased yields, thus decrease in use did not adversely affect yields. Attributing the yield increases to decreased hydrocarbon use is questionable.	4. Reference #2.
		5. Crop yields were shown to increase with decreased hydrocarbon use.	5. Casey, J. E., Lacewell, R.D., and Sterling W., "An example of economically feasible opportunities for reducing pesticide use in commerical agriculture," J. of Environ Quality 4(1): 60-64, 1975.

Continued . . .

Exhibit 5.1 & 5.2. (Continued)

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Environmental Effects	Conclusions	Research Findings	References
Resource Use	Fertilizer use and herbicide use remain unchanged. It has been determined that probably all herbicide applications are needed for effective weed control. In some areas, an estimated 40% of all insecticides applied are not needed in Illinois and 50% of all chlorinated hydrocarbons were not needed.	6. 40% of all acres in Illinois treated with insecticides did not need treatment. At least 50% of all acres in Iowa and Illinois treated with chlorinated hydrocarbons did not need treatment. Use of herbicides was needed and profitable on all acres treated.	6. Reference #2
Pollutant Changes in Media	Pesticide residues in water, soil, and air could greatly be reduced with reliable scouting use. However, large reductions are not likely to be seen until scouting can prove itself as a control method.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 5. Scouting and Integrated Controls

Subtrend: 5.3 Integrated controls

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	2010	Factors/Rationale
Aquatic	+1	+4	Target oriented
Terrestrial	+1	+4	Reduced effect on non-target organisms
Human Health	0	+2	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Pesticide use would be limited for the most part to target-organisms. This pesticide reduction would enhance both the aquatic and terrestrial systems through increased species diversity.

(2) Research needs:

a. Research and developments in this area need to be followed up with education in the benefits and application of these controls.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 5.3. Environmental assessment of selected agricultural trends: Crop Production
Trend: 5. Scouting and Integrated Controls
Subtrend: 5.3. Integrated controls

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Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Successful development of integrated controls depends on natural pest populations control, along with a combination of techniques that contribute to suppression, cultural methods, pest-specific diseases, resistant crop varieties, sterile insects, attractants, use of predators, or chemical pesticides as needed. Some of these methods are in their infancy and are not yet widely accepted or feasible to use. However, contemporary pesticide practices have proved effective to the farmer. Until those other practices are available for use and convincing evidence shows they offer more protection per unit of cost than current pest control methods, farmers will not adopt integrated controls. By 2010 integrated controls will probably be widely accepted and used.	1. Evaluation Workshop Ratings: Panel 1: 1976 2 ; 1985 4 ; 2010 5 . Panel 2: 1976 2 ; 1985 3 ; 2010 4 . 2. Current chemical pest control methods are effective. Farmers will not adopt integrated control methods until they become feasible for commercial use and can be shown to be as effective per unit of cost as current control methods.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1977. 2. National Academy of Sciences, Volume 1, Contemporary Pest Control Practices and Prospects, Washington, D.C., 1975.
Productivity	Productivity of integrated pest control will compare to productivity from chemical pest control methods. For example, yield increases occur with some insect resistant crops and with decreased use of chlorinated hydrocarbons.	3. Yields increase with some insect and disease resistant crops. 4. Crop yields were shown to increase with decreased chlorinated hydro carbon use. 5. Acres with decreased chlorinated hydrocarbon use since 1966, showed yield increases, showing decrease in use did not adversely affect yields. Attributing yield increase to decreased use is questionable.	3. See References for 7.4, Disease and insect resistant crops - productivity. 4. Casey, J. E., Lacewell, R.D., and Sterling, W. "An example of economically feasible opportunities for reducing pesticide use in commercial agriculture," J. of Environ. Quality 4(1):60-64, 1975. 5. U.S. Environmental Protection Agency, Farmers Pesticide Use Decisions and Attitudes on Alternative Crop Protecion Methods, 158 pages, 1974.
Resource Use	Fertilizer and herbicide use remain constant. Insecticide use would be greatly decreased. Cost could increase for some practices associated with integrated pest control.		

Continued . . .

Exhibit 5.3. (Continued)

Page 2

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media	Pesticide residues in water, soil, and air will be significantly reduced. Reductions will not be seen until integrated controls become feasible.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 6. Development of New Biological & Chemical Pesticides Subtrend: 6.1-6.5 Development of new chemical pesticides

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+1	+3	Beneficial effects of bio-degradable pesticides
Terrestrial	+1	+2	Greater species diversity
Human Health	+1	+2	Acute toxicity decreased

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Beneficial effects can be expected primarily from anticipated developments in and use of bio-degradable pesticides which are less toxic. This will enhance both the aquatic and terrestrial systems by increasing species diversity. Acute toxicity problems will be reduced in pesticide application. Also, overall pesticide use is expected to decrease. Potential problems can be foreseen in the development of systems and micro-encapsulated formulations.

(2) Research needs:

a. Research is needed in the environmental effects of these pesticides as they are developed including a study of systemic residues and the nature of degradation products.

b. Research is also needed on biomagnification of the food chain and effects of pesticides in the decomposing food chain.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 6.1. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: 6.1 Micro-encapsulated

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Research has only begun on microencapsulation of pesticides. Insufficient attention has been given to the basic release mechanisms. This is a promising area and may be used in future.	1. Evaluation Workshop Rating-- Panel I: 1976 _1_; 1985 _2_; 2010 _3_. 2. Research has only begun on microencapsulation of pesticides. Further research is needed to determine feasibility of use.	1. Dev. Planning and Research Assoc., Environmental Implications of Funds in Agriculture and Silviculture, Volume 1, 200 pp., 1977. 2. National Academy of Sciences, Volume 1, Contemporary Pest Control Practices and Prospects, Washington, D.C., 1975.
Productivity	Productivity would be comparable to productivity from conventional chemical pesticide control.		
Resource Use	Fertilizer and herbicide use remain constant. Insecticide use would decrease since efficiency is increased and fewer applications are needed.		
Pollutant Changes in Media:	Pesticide residues in water would be decreased since use decreases. Residues in air would also decrease since microencapsulation reduces loss through drift and volatilization. Persistence in soil may be increased with slow release pesticides.		

Exhibit 6.2. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: 6.2 Systemic pesticides

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Systemic pesticides are absorbed and translocated through the plant to which they are applied. They show promise, but more research is needed to determine the residue levels remaining in the plants at harvest time. Limitations and benefits of systemic pesticides have yet to be determined.	1. Evaluation Workshop Ratings: Panel 1: 1976 2 ; 1985 3 ; 2010 4 . 2. More research is needed to determine residue levels remaining in plants at harvest time. Limitations and potential benefits of this practice need to be further researched.	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pages, 1977. 2. National Academy of Sciences. Volume 1, Contemporary Pest Control Practices and Prospects, Washington, D.C., 1975.
Productivity	Productivity is expected to remain constant.		
Resource Use	Resource use will remain constant (Note: data is not available for pesticide use with systemic pesticides, but is assumed to remain unchanged.		
Pollutant Changes in Media	Change in pesticide residue levels in water, soil, and air is unknown, but assumed not to increase. A potential exists for increased pesticide residues in crops. More research is needed to determine if dangerous residue levels can result.		

Exhibit 6.3. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: 6.3 Surfactants for herbicides

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Much research is needed before surfactants are available for commercial use. Potential is high for this development and commercial use is anticipated for surfactants.	1. Evaluation Workshop Rating Panel 1: 1976 1 ; 1985 2 ; 2010 3 . 2. Research is needed for development of surfactants, but potential is high for surfactants.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pages, 1977. 2. National Academy of Sciences, Volume 1, Contemporary Pest Control Practices and Prospects, Washington, D. C., 1975.
Productivity	Productivity will remain unchanged or increase slightly. Increase would be due to increased efficiency of the herbicides.		
Resource Use	Fertilizer and insecticide use remain constant. Herbicide use could decrease as much as 50%. Cost of herbicide treatment would be reduced.	3. Herbicide requirement could be reduced by 50%.	3. Reference #2
Pollutant Changes in Media	Herbicide losses into water, soil, and air will be significantly decreased.	4. Herbicides account for 46% of total pesticides used by farmers in 1971. Surfactants could reduce this use by as much as 50%.	4. Reference #2

Exhibit 6.4. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: 6.4 Biodegradable Pesticides 1/

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Selective less toxic, biodegradable pesticides can and are being developed through research, and offers a solution to persistent pesticides as DDT, and to the toxic biodegradable pesticides that are currently available. Extensiveness will increase to 2010 when several selective, less toxic, biodegradable pesticides will be available. Cost of the pesticides is high in 1976 which decreases their use by farmers. Cost reductions will lead to wider use of the compounds.	1. Evaluation Workshop Ratings-- Panel 1: 1976 3 ; 1985 4 ; 2010 5 . 2. Selective biodegradable pesticides are being developed. They have a high toxicity to insects, yet are relatively safe to humans and higher animals. Two examples of these "new" pesticides are emphasized: a. Selectivity of parathion is being improved. These retain high toxicity to pests, yet are safe to man and higher animals. b. The biodegradability of DDT is being improved. The new analog will be persistent but not stored in the lipids of animals or concentrated in food chains.	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977. 2. National Academy of Sciences, Pest Control Strategies of the Future, Washington, D.C., 1972.
Productivity	Productivity remains unchanged.	No research data available.	
Resource Use	Fertilizer, herbicide , and insecticide use will remain unchanged. Cost of selective non-toxic biodegradable pesticides are higher because they are not as extensively used as more toxic pesticides. Research costs to develop these are also high, leading to increased pesticide cost.	3. Cost of newer biodegradable pesticides can be considerably higher.	3. Fox, A.S., "Economic consequences of restricting or banning the use of pesticides," pp. 34-49. In: Economic Research on Pesticides for Policy Decision Making, U.S. Dept. of Agric./Economic Research Service, Washington, D.C., 1971.
Pollutant Change in Media:	Pesticide residues in water, soil, and water remain constant. However, some biodegradable pesticides are more toxic to humans and animals. Selection and the use of less toxic biodegradable pesticides will reduce hazards to humans and animals.	4. Certain biodegradable pesticides, such as parathion, are highly toxic to animals. Several deaths have been caused to applicators of the pesticide.	4. Hoffman, C.H., "Restricting the use of insecticides-what are the alternatives?" pp. 14-21. In: Economic Research on Pesticides for Policy Decision Making, U.S. Dept. of Agric./Economic Research Service, Washington, D.C., 1971.

1/ Note: Discussion is limited to the development of newer selective, less toxic biodegradable pesticides. There are currently bio-degradable pesticides used widely in the U.S. However, these compounds are very toxic to humans and are often considered undesirable for use.

Exhibit 6.5. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: 6.5 Alternative Formulations

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	No accurate estimates can be made of the number of acres on which alternative formulations are being used. The workshop panel expect the use to be significant by 2010.	1. Extensiveness ratings assigned by the Crop Production Panel (Workshop) are as follows: 1976 1985 2010 3 4 5	1. Development Planning and Research Associates, Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977.
Productivity	The effectiveness of this practice would be reflected in increased crop yields.	2. The use of a series of pesticides and mixtures which differ in their effectiveness in controlling pests reduces the chance of a species that is tolerant to a specific pesticide from becoming dominant.	2. National Academy of Sciences, Pest Control Strategies of the Future, Washington, D.C., 1972.
Resource Use	The overall pesticide requirement would not be significantly changed although minor decreases could be expected as a result of increased effectiveness.		
Pollutant Change in Media	Slight reductions of residues in the soil and water can be expected.	The rotation of pesticides reduces the chance of an accumulation of pesticide residues in the soil.	3. Reference #2.

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 6. Development of New Biological & Chemical Pesticides Subtrend: 6.6-6.9 Development of new biological pesticides

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+1	+3	-----
Terrestrial	+1	+3	-----
Human Health	+1	+3	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Minor effects are expected by 1985 on the ecological system. Depending on the extensiveness of these developments, the effects are expected, to be of moderate importance by 2010. Developments are anticipated to have regional application.

(2) Research needs:

a. Research is needed principally in developments related to the use of predators and parasites and involve the effect of these agents on non-target organisms and their effects after the prey has been eradicated.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 6.6 & 6.7. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: 6.6 & 6.7. Juvenile Hormones and Phermones

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Extensiveness is limited in 1976. Research is promising, but commercial use may be 10 years away.	1. Evaluation Workshop Rating-- Juvenile Hormones Panel 1: 1976 1 ; 1985 2 ; 2010 4 . Pheromones Panel 1: 1976 1 ; 1985 2 ; 2010 4 .	1. Dev. Planning and Research Assoc., Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977.
		2. Research is on-going and looks promising. Commercial use is still a few years away. An experimental permit was granted in 1974 for experimental use of Altosid, a compound designed to interfere with pest metabolism.	2. National Academy of Sciences, Volume 1, Contemporary Pest Control Practices and Prospects, Washington, D.C., 1975.
Productivity	Productivity resulting from the use of these compounds is unknown. If they are to be widely used, productivity must be comparable to yields from chemical pest control methods. Large scale field tests are needed to determine how effective these compounds are in sustaining yields. Potentially, productivity could increase if a pest is eradicated or if pesticide residues in soil decrease.	3. Large scale field tests are needed to determine if these compounds can compete with chemical pesticides.	3. Reference #2.
Resource Use	Fertilizer and herbicide use remain constant. Insecticide use may not be greatly decreased because juvenile hormones and pheromones are usually specific for one pest. If more than one pest is present in one area, another insecticide may have to be applied. More applications of hormones and pheromones may have to be applied to effectively control a pest. Cost per unit of control with these compounds has not been determined.		
Pollutant Changes in Media:	Insecticide residues in soil, water, and air may remain constant or decrease. Residues will still be present with hormones and pheromones. However these residues are toxic only to insects and not to man or animals.		

Exhibit 6.8. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: 6.8 Sterile Males

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	U.S.D.A. is involved in a number of large scale programs designed to control certain insects by the release of sterile males. However, from a national perspective, this practice is not very extensive as reflected in the ratings of the workshop panel.	1. The crop production panel assigned the following extensiveness ratings to this trend: 1976 1985 2010 1 1 2 2. U.S.D.A. is involved in major efforts to control a number of insect populations to include the pink bollworm in the Southwest, the Mexican fruitfly in the subtropical areas of the United States, and the boll wevil in the Southeast and parts of the Southwest.	1. Development Planning and Research Associates, Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977. 2. National Academy of Sciences, Contemporary Pest Control Practices and Prospects: The Report of the Executive Committee, Volume 1, 1975.
Productivity	A slight increase in crop yields can be expected.		
Resource Use	Minor decreases can be expected in the overall chemical pesticide requirements.		
Pollutant Changes in Media	Minor to insignificant reductions in pesticide runoff and leaching would result from the associated reduction in chemical pesticide requirements.		

Exhibit 6.9. Environmental assessment of selected agricultural trends: Crop Production
Trend: 6. Development of New Biological and Chemical Pesticides
Subtrend: Predators and Parasites

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Although spectacular results have occurred with the use of predators and parasites in pest control, the wide range of technology necessary for excessive adoption of this practice has not been developed (Reference 1).		1. National Academy of Science, Contemporary Pest Control Practices and Prospects: The Report of the Executive Committee, 1975.
	The workshop did not expect this trend to become very important in the future.	The rating assigned by the crop production panel for this trend was 1 for 1976, 1985, and 2010.	2. Development Planning and Research Associates, Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pp., 1977.
Productivity	Although the use of predators and parasites in the control of both weeds and insects shows promise of increasing crop yields, no significant increase is expected in light of the limited use anticipated for the practice.		
Resource Use	No significant effect on resource use is expected. However, a reduction in pesticide requirement can be expected in those cases in which this practice is used.	The use of parasites in control of grape leafhoppers in California resulted in a net savings of $2.8 million in pest control costs over an eight year period.	3. Reference #1.
Pollutant Change in Media	This trend should not have any direct effects on pollutants in the soil, water, or air.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 7. Methods of Nutrient Application

Subtrend: 7.1 Foliar application

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	0	0	
Terrestrial	0	0	
Human Health	0	0	

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

No significant effects are expected from foliar application. This application technique is basically an adjunct to soil incorporation but may be a partial substitute.

(2) Research needs:

a. Ongoing research involving foliar application should address environmental implications.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 7.1. Environmental assessment of selected agricultural trends: Crop Production
Trend: 7. Methods of Nutrient Application
Subtrend: 7.1 Foliar application

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Extensiveness in 1976 is low. Research is on-going and there are limited production trials. Use of foliar application for soybeans in 2010 will increase as practice becomes accepted.	1. Evaluation Workshop Rating: Panel 1: 1976 1 ; 1985 2 ; 2010 2 . Panel 2: 1976 1 ; 1985 1 ; 2010 2 .	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1976.
Productivity	Limited research has shown yield increases up to 20 bu/acre for soybeans, however farmers can expect 0-10 bu/acre increases, depending on the original nutrient status of soils, the pre-plant application, and previous cropping pattern. Time of application, rate of application, and concentrations of nutrients must be carefully controlled to reduce the potential for leaf burns and reduced yields.	2. Yield increases with experimental use of foliar application ranged between 5-20 bu/acre. Average yield increases were about 9 bu/acre.	2. "Foliar fertilizing of soybeans risky yet." Crops and Soils 29(7):27-28, Apr., 1977.
Resource Use	Herbicide and insecticide use remain unchanged. Fertilizer use will remain unchanged to slight increases. Cost is higher for foliar application in 1976, but expected to decrease with time and commercial adoption of this practice.		
Pollutant Changes in Media: Surface Water	There will be less available N and P on the ground surface for runoff and this will cause decreases in nutrient losses to surface water.	3. Nutrients are absorbed directly from the crop leaf instead of through the crops root system.	3. Reference #2
Pollutant Changes in Media; Groundwater	Amount of N available for leaching is less, and reductions of N in groundwater will occur.		
Pollutant Changes in Media: Air	Potential drift problems can result with foliar application. Timing of applications can help eliminate this potential nutrient loss to the air.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 7. Methods of Nutrient Application

Subtrend: 7.2 Multiple applications

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	+1	+1	Reduced nutrient loss
Terrestrial	0	+1	Less leaching
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Effects are expected to be beneficial but of a minor nature. Less nutrients will be available for runoff at any one time. This would reduce eutrophication in surface water. There would also be less nitrogen available for leaching.

(2) Research needs:

a. Research is needed on the long term effects of leaching of other ions with nitrogen and movement of ions down in soil profile.

NOTE: This is a general research need not specifically related to this practice.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 7.2. Environmental assessment of selected agricultural trends: Crop Production
Trend: 7. Methods of Nutrient Application
Subtrend: 7.2 Multiple applications

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1976, more than 40% of applications are multiple applications. This practice will continue to increase to 2010. When the cost of high concentration show release fertilizers decrease, this will tend to replace multiple application.	1. Evaluation Workshop Ratings: Panel 1: 1976 3 ; 1985 3 ; 2010 4 . Panel 2: 1976 2 ; 1985 3 ; 2010 4 .	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pages, 1977.
Productivity	Yield increases from 20-40 bu/acre for corn have been obtained in research trials. Farmers can probably expect an increase in productivity but yield increases will not be this high.	2. Yield increases from 20-40 bu/acre were achieved for corn with multiple applications.	2. "Irrigation-fertigation round table," Crops and Soils 29(7): 14-21, 1977.
Resource Use	Pesticide use remains the same. Fertilizer use will be more efficient and use should decrease slightly. Increased energy and labor occur with multiple applications.	3. Two applications of nitrogen are more efficient and reduce fertilizer use.	3. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency. Control of Water Pollution from Cropland, Volume 2, Reprt 710, ARS-H-5-2, Washington, D.C., 1976.
Pollutant Changes in Media: Surface Water	Nutrients in surface water will remain unchanged or show slight decreases. There will be less N or P available at any one time for runoff loss. However, a single application of a better formulation could result in less nutrient in runoff compared to another application.		
Pollutant Changes in Media: Groundwater	Leaching of N will remain unchanged or decrease slightly. There is less N available at any one time for leaching.		
Pollutant Changes in Media: Soil	Slight increases of soil compaction will result.		
Pollutant Changes in Media: Air	No change		

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Trend: 7. Methods of Nutrient Application   Subtrend: 7.3 Fall applications

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	-2	-3	Significant nutrient losses during winter rains
Terrestrial	0	0	-----
Human Health	-1	-1	Nitrate runoff and leaching

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Significant effects of an adverse nature are expected on this aquatic system as a result of increased nutrient runoff. This increase occurs principally during winter rains and snow melt runoff. Generally, no appreciable effects are expected on terrestrial systems from a national perspective. Nitrate runoff into surface waters and leaching into ground waters pose potential health effects.

(2) Research needs:

a. Research is needed to determine the regional environmental impacts of fall application.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 7.3. Environmental assessment of selected agricultural trends: Crop Production
Trend: 7. Methods of Nutrient Application
Subtrend: 7.3 Fall applications

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1975, 39% of all fertilizers were fall applied. This practice is more important in non-irrigated crop production and will increase in use to 2010.	1. Evaluation Workshop Rating: Panel 1: 1976 3 ; 1985 3 ; 2010 4 . Panel 2: 1976 1 ; 1985 1 ; 2010 1 . 2. 39% of fertilizers in 1976 were fall applied	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pages, 1977. 2. National Fertilizer Development Center, TVA. 1976 Fertilizer Summary Data, 130 pages, 1976.
Productivity	Productivity values show large yield decreases to slight yield reduces to no change. Fall application is not advisable for many areas, especially for coarse textured, or fine sandy soils. Fall application of winter wheat and some other crops is desirable.	3. Productivity from fall applications of fertilizer can be greatly decreased with some crops and not effect yields with other crops.	3. "Irrigation-fertigation roundtable," Crops and Soils 29(7): 14-21, 1977.
Resource Use	Pesticide use remains the same. Fertilizer use will remain unchanged or show slight to significant increases. The fertilizer is less efficiently used. Leaching, run-off and denitrification through the winter will reduce the available nutrients in the spring. Fall application of fertilizer is convenient for the farmer and fertilizer manufacturer.	4. Fall applied fertilizer is less efficient. Winter losses of leaching and denitrification will occur.	4. U.S. Dept. of Agriculture/U.S. Environmental Protection Agency. Control of Water Pollution from Cropland, Volume I, Report No. ARS-H-5-1, Wash., D.C., 1975.
Pollutant Changes in Media: Surface Water Ground Water Air	The potential of N, P, and K in surface water is slightly greater for fall applied fertilizers in many areas. Potential leaching losses and air losses of N are increased with fall fertilizations.	5. Fall application of fertilizers is undesirable on some soil types. Fertilizer is generally limited to ammonium fertilizers which tend to reduce leaching.	5. Reference #3 and #4

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Trend: 7. Methods of Nutrient Application

Subtrend: 7.4 Liquid fertilizer

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	0	0	
Terrestrial	0	0	
Human Health	0	0	

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

The effects of liquid fertilizer application are not significantly different from those of solid fertilizer.

(2) Research needs:

a. Ongoing research involving liquid fertilizers should address the environmental implications.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 7.4. Environmental assessment of selected agricultural trends: Crop Production
Trend: 7. Methods of Nutrient Application
Subtrend: 7.4: Liquid fertilizer

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1975, 30% of all fertilizers were liquid compared to 8.5% in 1968. Use of liquid fertilizers will increase to major levels by 2010 and is the fastest growing segment of the fertilizer industry.	1. Evaluation Workshop Rating: Panel 1: 1976 3 ; 1985 4 ; 2010 5 . 2. Liquid fertilizer was 30% of all fertilizers in 1975. In 1968, only 8.5% of all fertilizers were liquid.	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Volume 1, 200 pages, 1977. 2. National Fertilizer Development Center, TVA. 1976. Fertilizer Summary Data, 130 pages, 1976.
Productivity	Productivity will increase slightly with liquid fertilizers on a pound for pound basis.	3. Production increases with liquid fertilizer on a pound for pound basis.	3. Allied Chemical, Iowa, public demonstrations.
Resource Use	Herbicide and insecticide use remain constant. Fertilizer use decreases slightly. Labor will decrease.		
Pollutant Changes in Media: Surface water Groundwater Soil	Changes in nutrient pollutants in surface and groundwater will remain unchanged or perhaps show a very slight decrease. Pollutant effects of liquid fertilizers are the same on a pound for pound basis. However, total fertilizer use will decrease slightly.		

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Trend: 7. Methods of Nutrient Application

Subtrend: 7.5 Aerial and floater application

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	2010	Factors/Rationale
Aquatic	0	0	-----
Terrestrial	+1	+2	Less soil compaction from floaters
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

No significant effects can be expected on either the aquatic system or human health. Floater application will have minor beneficial effects on the terrestrial system resulting from less compaction. Drift problems can be anticipated from aerial application; however, the overall effects will not be significant since this type of application represents a minor part of the total means of application.

(2) Research needs:

a. Ongoing research involving floater and aerial application should address environmental implications.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 7.5. Environmental assessment of selected agricultural trends: Crop Production
Trend: 7. Methods of Nutrient Application
Subtrend: 7.5 Aerial and floater application

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Extensiveness in 1976 may be more than 20% of all fertilizer applications. 1/ This practice will continue to increase to 2010.	1. Evaluation Workshop Ratings: Panel 1: 1976 1 ; 1985 2 ; 2010 2 . Panel 2: 1976 2 ; 1985 2 ; 2010 3 .	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1977.
Productivity	Slight productivity increases are expected with this practice. Areas difficult to treat with conventional fertilizer application methods, will benefit from aerial application.		
Resource Use	Resource use will remain constant, except for labor which decreases.		
Pollutant Changes in Media: Surface water Groundwater Soil	Data on nutrient pollutants in surface water, groundwater, and soil is not available. However, it is likely to remain unchanged.		
Pollutant Changes in Media: Air	Increased nutrient losses will occur with aerial application, by drift.		

1/ Ag Chem Corp. manufacturers of floater vehicles, estimated that in 1976 50% of crop acres were transversed at least once per year by floater vehicles to spread fertilizer.

The National Agricultural Aviation Association estimates that less than 5% of all crop acres are fertilized aerially, in 1976.

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Trend: 7. Methods of Nutrient Application

Subtrend: 7.6 Improved nutrient placement

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	0	0	-----
Terrestrial	0	0	-----
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Improved nutrient placement has the potential for beneficial effects from more effective utilization and less nutrient loss. However, the overall effects are not expected to be significant.

(2) Research needs: None identified.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 7.6. Environmental assessment of selected agricultural trends: Crop Production
Trend: 7. Methods of Nutrient Application
Subtrend: 7.6 Improved nutrient placement

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1976, an estimated 30% or more fertilizers had improved placement. This practice will increase slightly to 2010.	1. Evaluation Workshop Ratings Panel 1: 1976 4 ; 1985 4 ; 2010 4 . Panel 2: 1976 2 ; 1985 3 ; 2010 4 .	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1977.
Productivity	Productivity may increase slightly with optimum placement.	2. Decreased P in band applications can give higher yields than higher rates of P in broadcast. Yields for corn were 6 bu/acre higher for band application.	2. Richards, G. E. "Band Application: A better less costly way to fertilize your crops," Crops and Soils 28(9):10-11, 1976.
Resource Use	Herbicide and insecticide use remains constant. Fertilizer use will remain unchanged or show slight decreases, especially for P requirement. Fertilizer costs and application costs are reduced with P banding.	3. Band application of P can decrease use requirement by 50% and maintain yields.	3. Richards, G. E., "Phosphorus fertilization: can we do a better job?" Crops and Soils 27(4): 12-14, 1975.
Pollutant Changes in Media: Surface water Groundwater Soil	With improved nutrient placement, potential nutrient pollution of surface water and ground water will remain unchanged or show very slight decreases. Decreases would result from crops being able to more efficiently use the nutrients.		

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Trend: 7. Methods of Nutrient Application

Subtrend: 7.7 Irrigation application

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	-1	-1	Greater loss of nutrients in tailwater
Terrestrial	0	0	-----
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

The effects on the aquatic system are expected to be minor and of an adverse nature resulting from a slight increase of nutrients in tailwaters. No significant effects are anticipated on human health or the terrestrial systems.

(2) Research needs:

a. There is a need for research in comparing nutrient loss from irrigation and ground application.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 7.7. Environmental assessment of selected agricultural trends: Crop Production
Trend: 7. Methods of Nutrient Application
Subtrend: 7.7 Irrigation application

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	An estimated 25% of all irrigated cropland applied fertilizers in irrigation waters in 1976. Extensiveness will increase slightly by 2010.	1. Evaluation Workshop Ratings Panel 2: 1976 2 ; 1985 2 ; 2010 3 .	1. Dev. Planning and Research Assoc. Environmental Implications of Trends in Agriculture and Silviculture, Vol. 1, 200 pages, 1977.
Productivity	Irrigation application lends itself to multiple applications and optimal rates and timing for crops. With irrigation, crop productivity will always increase. However, productivity can be further increased with irrigation application of fertilizer.	2. Irrigation application of fertilizers lends itself to optimal fertilizer management and efficiency. Yields increased an avg. of 20 bu/acre in one study with multiple fertilizer applications. Irrigation application should apply water uniformly across field for maximum fertilizer efficiency.	2. "Irrigation-fertigation round table," Crops and Soils 29(7): 14-21, 1977.
Resource Use	Fertilizer, herbicide, and insecticide use remain constant. The cost of fertilizer that must be used in irrigation systems is higher. However these costs are offset by lower cost of applying fertilizer, and increased fertilizer efficiency.	3. Costs for water applied fertilizers are higher. However costs for applying fertilizers are lower.	3. Reference #2
Pollutant Changes in Media: Surface water Groundwater Soil	The potential of nutrient pollution of surface water, groundwater, and soil with irrigation application of fertilizers will depend upon the irrigation management and scheduling practices. Irrigation application would probably tend to slightly reduce nutrient losses. However, over irrigation or rapid application rates would increase potential nutrient pollutants.	4. With good irrigation management, little N is available for leaching.	4. Reference #2
Pollutant Changes in Media: Air	With sprinkler irrigation, increased loss of nutrients to the air will occur on windy days.		

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Trend: 8. Using Soil Plant Analysis

Subtrend: 8.1 Soil plant analysis

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	±1	±2	Depends on type of nutrient application
Terrestrial	0	0	-----
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

Higher yields expected in the future will require higher rates of nutrient application. The effects of soil plant analysis on the aquatic systems will depend on how the nutrients are applied. Multiple applications and use of slow release fertilizer will result in beneficial effects; however, fertilizer over applied will have adverse effects. Beneficial effects would reflect rates based on demand and a more effective balance between nutrients. No significant effects are expected on human health or the terrestrial systems.

(2) Research needs:

a. Research involving analytical techniques should address environmental implications.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 8.1. Environmental assessment of selected agricultural trends: Crop Production
Trend: 8. Using Soil-Plant Analysis
Subtrend: 8.1 Soil Plant Analysis

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	An estimated 20-25 percent of cropland was covered by some type of soil analysis in 1976 while less than 5 percent was covered by plant analysis. Since these analyses are normally conducted no more than once every three years, the maximum cropland that could be expected to be covered in any given year would be 33 1/3 percent. It is anticipated that the annual coverage in 2010 will be less than 30 percent.	The following ratings of extensiveness were made by the crop production panels in connection with this trend: Panel — 1976 — 1985 — 2010 Nonirrigated Crop Production — 3 — 4 — 5 Irrigated Crop Production — 1 — 2 — 3	1. Development Planning and Research Associates, Environmental Implications of Trends in Agriculture and Silviculture, Volume I, 200 pp., 1977.
Productivity	Increases in crop yields can be expected from the trend towards plant-soil analysis.		
Resource Use	Some increase can be expected in fertilizer use as a result of the trend towards greater coverage by these types of analysis.		
Pollutant Change in Media	Although fertilizer use is expected to increase, the greater efficiency associated with plant-soil analysis would tend to decrease nutrient runoff and leaching. However, this reduction can be expected to be minor.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 9. Alternative Residual Disposal

Subtrend: 9.1 Off-site disposal

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	Ecological Effect Rating 1/ 2010	Factors/Rationale
Aquatic	-1	-2	Increased eutrophication, accelerated algae blooms
Terrestrial	+1	+1	Soil rehabilitation
Human Health	-1	-1	Potential nitrate pollution of ground water

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

The potential of nitrogen runoff is greater for manure than commercial fertilizer. The increase in nitrogen and BOD in surface water can be expected to increase eutrophication and to accelerate algae blooms. The organic content of manure can be expected to contribute to soil rehabilitation (this assumes a reduction in salt applied to rations). The potential of nitrate pollution in ground water poses problems in well water.

(2) Research needs:

a. Additional research is needed on the effects of high sodium content in rations on soil defloculation.

b. The economic feasibility of hauling manure for fertilizer use should be determined.

c. The use of rotations to effectively reduce the potential build-up of copper, arsenic, and sodium found in feed rations should be investigated.

d. Continued research is needed on the long term effects of nitrates on humans.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 9.1. Environmental assessment of selected agricultural trends: Feedlot Operations
Trend: 9. Alternative Residual Disposal
Subtrend: 9.1 Off-site Disposal of Solids and Liquids

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	About 2 billion tons of animal waste are being produced annually with less than a third, or about 500 million tons, generated in feedlots. Within feedlot operations, waste production is expected to increase by about 30% in 1985 and by 70% in 2010. The greatest portion of off-site disposal can be expected to be accomplished by land application. Although land application includes spreading for fertilization of crops as well as land disposal, most of the off-site application can be expected to be done at the higher disposal rates. Very few states have specifically prescribed maximum allowable rates. Of those few that do have these rates, the typical level is about 40 tons per acre per year. At this rate, the 30% and 70% increase in waste production would require a maximum of 4 million additional acres in 1985 and 8 million in 2010 for disposal.	About 1.56 billion tons of animal waste was produced annually (1972) including feedlots, range and pasture, and farms. (ref. 1) The relation between food production and animal waste is shown below: (ref. 2) To Produce — Produces Milk, 1 lb. — Manure, 2 lb. Chicken, 1 lb. — Manure, 8 lb. Beef, 1 lb. — Manure, 25 lb. The feedlot panel of the Evaluation Workshop rated the extensiveness of off-site disposal as follows: (ref. 5) 1976 1985 2010 Solids 2 3 4 Liquids 1 2 3 (1 = minor effect to 5 = major effect)	1. Inglett, G.E., "The Challenge of Waste Utilization," Symposium: Processing Agricultural and Municipal Wastes, Avi, West Port, Conn., 1973. 2. Stavenger, P., "The Food Industry and Pollution," Food Technology, 24, 121, 1970. 3. Draft Development Document for Effluent Limitations Guidelines and Standard Performance, Feedlot Industry, prepared for the Environmental Protection Agency by Hamilton Standard, 1973. 4. "Control of Pollution from Animal Feedlots," Hearings before a subcommittee of the Committee on Government Operations, House of Representatives, 93rd Congress, 1973. 5. U.S. Environmental Protection Agency, Environmental Implications of Trends in Agriculture and Silviculture. Phase I-The Evaluation Workshop Summary (DRAFT), prepared for EPA by Dev. Planning & Res. Assoc., 1977.
Productivity	The increased land disposal of animal waste will have both beneficial and adverse effects on plant productivity. Crop yields associated with manure application can generally be expected to be equivalent to yields resulting from commercial fertilizer. Yields frequently will depend on climatic conditions. In dry years, manure can be expected to have the greatest beneficial effects. In wet years commercial fertilizer will have the greatest beneficial effects.	When optimal rates of chemical fertilizers and animal waste are applied on separate plots, usually the yield will be equal. In dry years, manure produces the greatest yields; in wet years, chemical fertilizer produces the greatest (ref. 6-7). Increased soil salinity resulting from land application has been found to decrease crop yields. (ref. 8) Applications of beef and dairy waste have increased the nitrate-nitrogen content of plants to levels potentially toxic to animal health. (ref. 10-11) Copper concentrations in grasses receiving waste from swine grown on high copper ration were reported above 30 ppm, the toxic threshold for sheep. (ref. 12)	6. McIntosh, J. L., and K. E. Varney, "Accumulative Effects of Manure and N on Continuous Corn and Clay Soil. I. Growth Yield, and Nutrient Uptake of Corn, "Agron. J., 64: 374-378, 1972. 7. Ware, L.M., and W. A. Johnson, "Poultry Manure for Vegetable Crops --Effects and Value, Bull. 386, Agricultural Exp. Station, Auburn Univ., Auburn, Albama, 1968. 8. Mathers, A. C. and B. A. Stewart, "Crop Production and Soil Analyses as Affected by Applications of Cattle Feedlot Waste," Livestock Int. Symposium on Livestock Wastes, American Society of Agr. Engr., St. Joseph, Michigan, 1971.

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Exhibit 9.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Productivity (Continued)		Arsenic content of legumes was found to be unaffected by applications of poultry litter containing measurable amounts of arsenic. (ref. 13)	9. Wallingford, G. W., L. S. Murphy, W. L. Powers, and H. L. Manges, "Effect of Beef-Feedlots Lagoon Water on Soil Chemical Properties and Growth and Composition of Corn Forage," J. Environmental Quality 3:74-75, 1974. 10. Mathers, A. C., and B. A. Stewart, "Corn Silage Yield and Soil Chemical Properties as Affected by Cattle Feedlot Manure," J. Environ. Quality, 3:143-147, 1974. 11. Pratt, P. R. S. Davis, R. G. Sharpless, W. J. Pugh, and S. E. Bishop, "Nitrate Content of Sudangrass and Barley Forages Grown on Plots Treated with Animal Manures," Agron. J., 1974. 12. Humenik, F. J., R. W. Skaggs, C. R. Willey, and D. Huisingh, "Evaluation of Swine Waste Treatment Alternatives," Waste Management Research, Graphics Corp., Washington D.C., 1972. 13. Morrison, J. L., "Distribution of Arsenic from Poultry Litter in Broiler Chickens, Soil, and Crops," J. Agri. and Food Chem., 17:1288-1290, 1969.
Resource Use	Increased animal waste production can be expected to result in increased fertilization with manure which will tend to offset, to a small degree, the overall commercial fertilizer requirements. Increased land application can be expected to increase fly infestation with an increase in pesticide requirement. However, the increase in pesticide use is not expected to be significant.		
Pollutant Changes in Media: Surface Water	Available research on the possible pollution of surface water has primarily involved measurement of nutrient runoff. At fertilization rates (10-20 tons/acre), nutrient	From field experiments in Vermont, 1936-1943: (ref. 14) a. Greatest runoff occurred in Feb. and March;	14. Medgby, A.R., and D.E. Dunklee, "Fertility Runoff Losses from Manure Spread during the Winter," Univ. of Vermont, Ag. Exp. Sta., Bull. 523, 1945.

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Exhibit 9.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Surface Water (Continued)	runoff associated with animal waste would be relatively minor and, in most cases would be less than the runoff associated with equivalent rates of commercial fertilizers. When animal waste is applied on frozen ground or in early spring, runoff up to 30% of the available nitrogen can be expected. Research on high disposal rates have primarily been designed to measure the effects on crop yield not nutrient runoff. Several experiments involving these rates have shown that nutrient runoff has not been significantly greater than that of untreated land. No specific research is available directly linking sediment loss with land disposal. However, based on research showing generally reduced runoff with land disposal, it can be concluded that sediment loss would also be reduced.	b. Average nutrient losses after an application of ten tons of untreated manure were: nitrogen equivalent to from 20 to 70 lbs. of sodium nitrate; phosphorus, equivalent to from 12 to 25 lbs. of 20% superphosphate; and potassium, equivalent to from 27 to 55 lbs. of 50% muriate of potash; c. Volatilization losses were usually greater than runoff losses because they begin to occur as soon as the manure is produced, and much of the ammonia is lost into the air before runoff occurs. A study on the application of liquid dairy waste on sloping frozen land found that a rate of 130 cumulative wet tons per hecture increased the ammonium nitrogen and total coliform in the runoff. However, the total nitrogen measured in the runoff was not affected. (ref. 15) From field experiments in Wisconsin 1966-1959, on Rosetta silt loam soil the following conclusions were made: a. Up to 20% of N, 13% of P, and 13% of K nutrients in winter applied manure on frozen ground, may be lost under conditions favoring maximum early spring runoff; b. Nutrient losses in surface runoff from plots having manure applied in the summer and incorporated into the soil were less than from check plots which received no manure. (ref. 16) A comparison of the effects of winter and spring application of dairy manure revealed that nutrient losses from winter applications were extremely variable--3.4 to 26.9 Kg/ha of nitrogen. Spring application resulted in no runoff losses of N, P, or K. (ref. 17)	15. Sutton, A.L., D.W. Nelson, N.J. Moeller, and L.F. Huggins, "Application of Anaerobic Liquid Dairy Waste on Sloping Frozen Land," presented at the 69th Annual Meeting of the Amer. Dairy Science Assoc., Univ. of Cuelph, Canada, 1974. 16. Minshall, N.E., S.A. Witzel, and M.S. Nichols, "Stream Enrichment from Farm Operations," Proc. Amer. Soc. Civil Engr. Sanitary Engr., Div. Sr. SA 2:513-524, 1970. 17. Henster, R.F., W.H. Enhardt, and L.M. Walsh, "Effects of Manure Handling Systems on Plant Nutrient Cycling," Livestock Waste Management and Pollution Abatement, Proc. Int. Symposium on Livestock Wastes, p. 254-257, Amer. Soc. of Agr. Eng., St. Joseph, Michigan, 1971. 18. Young, R.A., "Nutrients in Runoff from Manure Spread on Frozen Ground," Transactions of the ASAE, 1973. 19. McCaskey, T.A., G.H. Rollins, and J. Little, "Water Pollution by Dairy Farm Wastes as Related to Method of Waste Disposal," Water Resources Research Institute Bulletin 18, 1973. 20. Crose, O.E., A.P. Mazurah, Leon Chesnin, "Animal Waste Utilization for Pollution Abatement," Transactions of the ASAE, 16,1:160-163, 1973. 21. Lund, Z.F., F. L. Long, B.D. Doss, and Luke Mugwira, "Disposal of Dairy Cattle Manure on Soil," International Symposium on Livestuck Waste at Urbana-Champaign, 1975.

continued . . .

Exhibit 9.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Surface Water (Continued)		From a study on the effects of vegetation cover on dairy manure runoff the following observations were made: a. When manure was applied to frozen alfalfa land, 30% of the applied nitrogen and 6% of the applied orthophosphate was lost; b. Nutrient loss from the alfalfa plots was greater than from untreated plots; c. When manure was applied to frozen, plowed land, nutrient losses were only slightly greater than those from the untreated plots. (ref. 18)	
		Research was done in Alabama during a 27 month period between 1969 and 1970 involving spreading of manure on grassland plots. Findings revealed that the most BOD and nitrate in runoff during 1971 from spreading occured during August, the month of lowest rainfall; the least occurred during March. At 10 to 21 tons waste applied annually on grassland, there was not an appreciable deterioration of runoff water quality nor buildup soil nitrate. (ref. 19)	
		Research was conducted in Nebr. with the objective of determining the maximum allowable rate of applying livestock manure to cultivate crops without pollution of surface runoff or under ground water. Beef feedlot manure was applied at levels of 0, 40, 120, and 260 tons dry matter/acre and disk plowed into the soil at 4, 8, . and 12 inch depths. Conclusions made were that N and sodium displacement did not pollute the surface runoff water; however, potassium restricted the runoff to irrigation uses only. Ground water retained its potable quality (the 260 ton/acre test area contributed 7.8 ppm of nitrate nitrogen. Ten ppm is the maximum allowable). (ref 20)	

continued . . .

Exhibit 9.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Surface Water (Continued)		In Alabama, dairy cattle manure was incorporated into the surface (15 cm) of Norfolk sand loam cropped with millet and rye for a period of three years and at a rate of 45 mt/ha/yr. Total N in runoff averaged less than 3 Kg/ha/yr. (ref. 21)	
Pollutant Changes in Media: Ground Water	Increased land application of animal waste can be expected to cause a greater potential for ground water pollution. Nitrate nitrogen and soluble salts have been found in ground water in vicinity of manure application sites.	Research conducted in California on the effects of land application of dairy waste revealed that nitrate nitrogen and soluble salts were present in vicinity of the application sites. (ref. 22) In a study in Pennsylvania, liquid dairy manure was injected on plots of orchard grass, bluegrass and corn at rates supplying 200 to 600 pounds of nitrogen on the bluegrass and orchard grass in the soil water at 3 to 4 feet was approximately two times the limit for potable water. The level decreased 50% in the next growing season. It was estimated that continued annual applications on a relatively level silt loam soil should supply not more than 200 to 300 pounds of nitrogen per acre. (ref. 23)	22. Adriano, D.C., P.F. Pratt, and S.E. Bishop, "Fate of Organic Forms of N and Salt from Land-disposal Manures from Dairies," Livestock Waste Management and Pollution Abatement Proc. Int. Symposium on Livestock Wastes, P. 243-246, Amer. Soc. of Agr. Eng., St. Joseph, Michigan, 1971. 23. Marriott, L.F. and H.D. Bartlett, Animal Waste Contribution to Nitrate Nitrogen in Soil," International Symposium on Livestock Wastes at Urbana-Champaign, 1975.
Pollutant Changes in Media: Soil	Application of manure can generally be expected to increase soil infiltration and improve its water holding capacity. Total soil nitrogen can be expected to increase; however, research findings have not shown that the buildup is necessarily at undesirable levels.	A single application of 13.5 t/ha of solid dairy manure increased soil infiltration rate by 27% in a continuous corn culture. (ref. 24) Wet solid beef manure applied at a rate of 112 t/ha in Texas did not significantly affect the infiltration rate. (ref. 25) Infiltration rates increased with manure application rates from 93 to 269 t/ha; but decreased with higher rates. (ref. 26) Treated plots had larger yield increases in dry years than in wet years because of improved water availability. (ref. 27-28) Application of manure increased the available water capacity of the soil. (ref. 29)	24. Zwerman, P.J., A.B. Drielsma, G.D. Jones, S.D. Klausner, and D. Ellis, "Rates of Water Infiltration Resulting from Applications of Dairy Manure," Relationship of Agriculture to Soil and Water Pollution, Proc. 1970 Cornell Agricultural Waste Management Conf., p. 263-270, Graphics Management Corp., Washington, D.C., 1970. 25. Swader, F.N., and B.A. Stewart, "The Effect of Feedlot Wastes on the Water Relations of Pullman Clay Loam," ASAE Paper No. 72-959, Cornell University, 1972 Annual Mtg. ASAE, Hot Springs, Ark., June 27-30, 1972.

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Exhibit 9.1. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Soil (Continued)		Application of manure improved water availability by decreasing the force with which it was held in soil. (ref. 30) Heavy applications of solid feedlot waste and dairy manure slurry increased the total nitrogen in soil. (ref. 31-33) Research conducted in semi-arid Alberta to determine the effect of long-term applications of manure on N, P, and soluble salt content of cultivated soil under irrigation. Manure applied annually over a forty year period at 70 t/ha did not cause an undesirable buildup of the nutrients or salts. (ref. 34)	26. Manges, H.L., D.E. Eisenhauer, R.D. Stritzke, and E.H. Goering, "Beef Feedlot Manure and Soil Water Movement," Paper No. 74-2019, presented at the 1974 Summer Meeting, ASAE, Stillwater, June 23-26, 1974. 27. Haworth, F., T.V. Cleaver, and J.M. Bray, "The Effects of Different Manurial Treatments on the Yield and Mineral Composition of Early Potatoes," J. Hort. Sci., 41:225-241, 1966. 28. Holliday, R., P.M. Harris, and M.R. Baba, "Investigations into the Mode of Action of Farmyard Manure. I. The Influence of Soil Moisture Conditions on the Response of Maincrop potatoes to Farmyard Manure," J. Ag. Sci. 64:161-166, 1965. 29. Gingrich, J.R. and R.S. Stauffer, "Effects of Long-time Soil Treatments on Some Physical Properties of Several Illinois Soils," SS SAP 19:257-260, 1955. 30. Salter, P.J. and F. Haworth, "The Available Water Capacity of a Sandy Loam Soil," J. of Soil Sci. 12:335-342, 1961. 31. Herron, G.M. and A.B. Erhart, "Value of Manure on an Irrigated Calcareous Soil," SSSAP 29:278-281, 1965. 32. Mathers, A.C., and B.A. Stewart, "Corn Silage Yield and Soil Chemical Properties as Affected by Cattle Feedlot Manure", J. Environ. Quality 3:143-147, 1974. 33. Murphy, L.S., G.W. Wallingford, W.L. Powers, and H.L. Manges, "Effects of Solid Beef Feedlot Wastes on Soil Conditions and Plant Growth," Waste Management Res., Proc. 1972 Cornell Univ. Agr. Waste Management Conf, p. 449-464, Graphic Mgm. Corp., Washington, D.C., 1972.

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Exhibit 9.1. (Continued) Page 7

Environmental Effects	Conclusions	Research Findings	References
			34. Sommerfeldt, Theron G., U. J. Pittman, and R. A. Milne, "Effect of Feedlot Manure on Soil and Water Quality", J. Environmental Quality, 2, 4:423-427, 1973.

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 10. Grazing Practices and Stocking Rates

Subtrend: 10.1 Continuous grazing & 10.2 Specialized grazing

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	+1	+2	Beneficial effects from reduced runoff
Terrestrial	+2	+3	Species diversity increased
Human Health	0	0	No significant effect on ground water

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

The reduced runoff can be expected to have beneficial effects on surface water. The increased productivity in vegetation will increase species diversity. No significant effect is anticipated on ground water.

(2) Research needs:

a. There is a need for research on nutrient and sediment runoff associated with the various specialized systems.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 10.1 & 10.2. Environmental assessment of selected agricultural trends: Range and Pasture Management
Trend: 10. Grazing Practices and Stocking Rates
Subtrend: 10.1 & 10.2. Continuous grazing and 10.2 Specialized grazing

Page 1

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Information was not found in the literature indicating the number of acres currently under the various grazing systems: continuous vs. specialized. Estimates on range can be made from data contained in reference 1, making certain broad assumptions. That study made estimates for 1970 and 2000 concerning four strategies: "some grazing," "extensive," "intensive," and "environmental management." Assuming that the first two strategies correspond with continuous grazing and the latter two with specialized grazing, the extensiveness of the two systems are estimated as follows for 1970 and 2000. System / 1970 / 2000 (mil. ac.) / Change Continuous / 641.2 / 515.3 / -19.6% Specialized / 108.1 / 273.8 / +153.3% (No estimates are made on pasture)	1. The following strategies were developed under Alternative 19, which represents an accumulation of knowledge and constraints acquired in the evaluation of previous alternatives: Strategy B: some grazing - no attempt to achieve livestock distribution. Strategy C: extensive management - relative uniform livestock distribution with no attempt at maximizing forage production. Strategy D: intensive management - maximizing forage production using all available technology. Strategy E: environmental management - livestock production maximized. Strategy / 1970 / 2000 (mil. ac.) B / 236.2 / 155.8 C / 405.0 / 359.5 Subtotal / 641.2 / 515.3 D / 57.9 / 208.6 E / 50.2 / 65.2 Subtotal / 108.1 / 273.8	1. U. S. Department of Agriculture The Nations Range Resources, Forest Resource, Rep. No. 19, 1972.
Productivity	Specialized grazing systems can generally be expected to produce a higher quality forage than continuous systems.	2. Rotation grazing increased litter cover, decreased bare soil, increased water absorption (infiltration), decreased sod compaction, and increased basal cover of desirable plants. (However, there was no significant difference in total basal cover of all plants.)	2. Ratliff, R. D., J. N. Reppert, and R. J. McConnen, "Pest-rotation grazing at Harvey Valley ... range health, cattle gains, costs," Forest Service Research Paper PSW-77, Pacific S.W. Forest and Range Exp. Sta., Berkeley, Calif., 1972.
		3. Research in semi-desert sagebrush-bunch grass range found that vegetation increased 22 percent in density under continuous grazing and 20 percent under rotation.	3. Hyder, D.N., and W. A. Sawyer, "Rotation-deferred grazing as compared to season-long grazing on sagebrush-bunchgrass in Oregon," J. Range Management 4:30-34, 1951.

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Exhibit 10.1 & 10.2. (Continued)

Environmental Effects	Conclusions	Research Findings	References
		4. Research in Utah involving rotation and continuous grazing on crested wheat grass found that there was no significant difference in live basal area among rotation grazing, continuous grazing, and continuous grazing and delayed 10 days.	4. Freschknecht, N.C., and L. E. Harris, "Grazing Intensities and Systems on Crested Wheat Grass in Central Utah; Response of Vegetation and Cattle," Tech. Bull. No. 1388, Forest Service, USDA, Wash., D.C., 1968.
		5. In Medicine Bow National Park, plant cover density improved among three systems: continuous, rotation, and rest-rotation; however, the improvement was greater among rotation and rest-rotation.	5. Johnson, W.M., "Rotation, Rest-Rotation, and Season-long Grazing on a Mountain Range in Wyoming," Forest Service Research Paper RM-14, Rocky Mt. Forest and Range Exp. Sta., Fort Collins, CO,1965.
		6. In the northern plains, plant density declined from 50-60 percent to 30-40 percent under continuous grazing.	6. Rogler, G.A., "A Twenty-five Year Comparison of Continuous and Rotation Grazing in the Northern Plains," J. Range Management, 4:35-41, 1951.
		7. No significant difference in vegetation density was found between continuous and rotation grazing; although differences were found in the effects of individual species.	7. McIlvain, E.H., and D. Savage, "Eight-year Comparisons of Continuous and Rotational Grazing on the Southern Plains Experimental Range," J. Range Management, 4:42-47, 1951.
		8. In a five-year study in Texas, basal cover increased 2.7 percent under rotation grazing and 6.7 percent under continuous.	8. Fisher, C.E., and P.T. Marion, "Continuous and Rotation Grazing on Buffalo and Tobasa Grassland," J. Range Management, 4:48-51, 1951.
		9. A nine-year study of grazing in Alberta found no differences in increased ground cover by the main forage species, forbs, or shrubs.	9. Smoliak, S., "Effects of Deferred-Rotation and Continuous Grazing on Yearling Steer Gains and Short Grass Prairie Vegetation of Southeastern Alberta," J. Range Management, 13:239-243, 1960.
		10. A six-year study of grazing in Western Canada found that grasses increased in basal area from 7.3 percent to 7.4 percent under rotational systems and decreased from 7.9 percent to 7.2 percent under continuous.	10. Hubbard, W.A., "Rotation Grazing Studies in Western Canada," J. Range Management, 4:25-29, 1951.

Continued ... .

Exhibit 10.1 & 10.2. (Continued)

Environmental Effects	Conclusions	Research Findings	References
		11. In a study of native grasses in the rolling plains of Texas, deferred-rotation systems were found to produce vegetation as well as better than continuous systems.	11. Mathis, Gary W., and M. M. Kothmann, "Response of Native Range Grasses to Systems of Grazing and Grazing Intensity," Agronomic Research in the Texas Rolling Plains, PR-2626, p-22-23, 1968.
		12. Three reports found deferred-rotation systems to be generally of little or no advantage to vegetation. All of the reports agree that the maximum gains per head can be achieved with moderate continuous grazing.	12. Clarke, S.E., E.W. Tisdale, and N.A. Skoglund, "The Effects of Climate and Grazing Practices on Shortgrass Prairie Vegegation in Southern Alberta, and Southwestern Saskatchewan," Canadian Dept. Agr. Tech. Bull. 46, 53 p., 1943. 13. Whitman, W., F. W. Christensen, and E. A. Helgeson, "Pasture Grasses and Pasture Mixtures for Eastern North Dakota," N. Dak. Agr. Exp. Stat. Bull. No. 327, 1943. 14. Rogler, G.A., R. J. Lorenz, and M. Schoof, "Progress with Grass," N. Dak. Agr. Exp. Sta. Bull. No. 439, 15 p., 1962.
Resource Use	The trend toward specialized grazing systems would not have any direct impact on resource requirements.		
Surface Water	The generally improved vegetation under specialized systems would tend to reduce sediment and nutrient runoff.	13. There is no literature available which directly link runoff rates with the various grazing systems.	
Groundwater	Increased leaching associated with improved vegetation may potentially reduce the quality of groundwater.		
Soil	Trend toward specialized systems would have favorable impacts on soil conditions.	14. Rotation grazing decreased bare soil, increased the infiltration rate and decreased compaction.	14. Reference 2.

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 10. Grazing Practices and Stocking Rates

Subtrend: 10.3 Complementary forage seedings

TYPE OF EFFECT	Ecological Effect Rating 1/ 1985	2010	Factors/Rationale
Aquatic	0	0	Potential increase in runoff (during renovation)
Terrestrial	0	-1	Plant diversity decreased with monoculture
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

The overall ecological effect from this trend is expected to be relatively insignificant. The growing of tame grass can be expected to have a minor negative effect in 2010 resulting from a decrease in plant diversity.

(2) Research needs:

a. This practice is currently in the experimental stage. As the system is further developed, research is needed on its environmental impact.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 10.3. Environmental assessment of selected agricultural trends: Range and Pasture Management
Trend: 10. Grazing Practices and Stocking Rates
Subtrend: 10.3 Complementary Forage Seedings

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Information is not available in the literature from which estimates can be made on the extensiveness of trends towards complementary forage seedings. The range and pasture panel estimated the extensiveness to be of minor importance in 1976 but expected it to be of moderate significance in 2010.	1. The range and pasture (Workshop) assigned the following extensiveness ratings: 1976 1985 2010 1 2 3	1. U.S. Environmental Protection Agency, Environmental Implications of Trends in Agriculture and Silviculture: Phase I - The Evaluation Workshop Summary (Draft) Prepared by Development Planning and Research Associates, 1977.
Productivity	Productivity in both forage and beef is enhanced under this system. Improvement in vegetation can be expected with less pressure on ranges from overgrazing.	2. Permanent pastures used (under complementary forage seeding systems) balance the yearly forage supply and prevents overgrazing. Increased production has been shown in forage-production studies involving native prairie and crested wheatgrass.	2. Stoddart, L.A., A. D. Smith, and T. W. Box, Range Management, McGraw-Hill, New York, N.Y., 1975.
		3. A comparison of continuous grazing and a system using crested wheatgrass and native grass found that herbage production was about the same under each system even though the latter system supported 32 percent more animal unit months of grazing and produced 70 percent more pounds of beef per acre.	3. Lodge, R.W., "Complementary Grazing Systems for Sandhills of the Northern Great Plains," J. Range Management 16:240-244, 1963.
		4. A comparison of grazing under a continuous system and under a system utilizing 20 percent crested wheatgrass, 50 percent native grass, and 30 percent Russian wildrye found that 25.6 acres were required per animal unit under the continuous system as opposed to 11.4 acres under the complementary system.	4. Smoliak, S., "Grazing Studies on Native Range, Crested Wheatgrass and Russian Wildrye Pastures," J. Range Management, 21:47-50, 1968.
Resource Use	The utilization of this system increases the requirement for fertilizers, pesticides and land with the provision of additional pasturage (Reference 2).		

Continued . . .

Exhibit 10.3 (Continued)

Page 2

Environmental Effects	Conclusions	Research Findings	References
Surface Water	The increasing use of this system can be expected to have both short-term and long-term effects on the quality of surface water. In the short-term, potential pollution by nutrients and pesticides may occur during pasture renovation. In the long term, decreases in sedimentation can be expected with improved vegetation cover with prevention of overgrazing. The overall impact should be relatively minor.	For information on the effects of overgrazing, refer to research findings in Subtrend 10.4.	
Groundwater	Potential pollution from nutrients and pesticides can be expected from pasture renovation. The overall impact is considered to be minor.		
Soil	The overall impact of this trend is expected to be minor. A possible reduction in soil compaction would occur with the decrease in overgrazing. Potential soil pollution may occur with pasture renovation.		

Evaluation Sheet for Trends in Agriculture/Ecology Workshop

Trend: 10. Grazing Practices and Stocking Rates

Subtrend: 10.4 Controlled livestock grazing (proper use)

TYPE OF EFFECT	Ecological Effect Rating 1/		Factors/Rationale
	1985	2010	
Aquatic	+1	+1	-----
Terrestrial	+1	+3	Greater plant diversity
Human Health	0	0	-----

SUMMARY STATEMENT

(1) Potential ecological effects 2/:

This subtrend is expected to have a minor beneficial effect on the aquatic system. Greater plant diversity would have a beneficial effect on the terrestrial system. This effect was expected to be moderate by 1985.

(2) Research needs:

a. There is a need for research of the nutrient and sediment runoff associated with controlled grazing.

1/ Rating: ± (1 to 5) where 1=minor, 3=moderate, and 5=major ecological effect. A plus (+) rating denotes a positive or beneficial effect; a negative (-) rating denotes a negative or adverse effect.

2/ Include specification of regional implications as needed.

Exhibit 10.4. Environmental assessment of selected agricultural trends. Range and Pasture Management
Trend: 10. Grazing Practices and Stocking Rates
Subtrend: 10.4 Controlled livestock grazing (Proper use)

Page 1

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	In 1970, an estimated 85.7 million acres or 10% of the grazed forest-range was being overgrazed; close to 85% of this occurred in the Eastern forests. The goal under the Forest and Rangeland Renewable Resource Planning Act of 1974 is to reduce the overgrazed areas to zero by 2000. No estimates are made on overgrazing on pastures.	1. The following acres of forest-range were under exploitive management (overgrazing) in 1970: Ecosystem — Total grazed (mil. ac.) — Overgrazed — Percent Western range — 360.8 — 10.1 — 2.8 Western forests — 97.2 — 2.2 — 2.3 Great Plains — 217.1 — 0.9 — 0.4 Eastern forests — 159.9 — 72.4 — 45.3 Total — 835.0 — 85.7 — 10.2 The extensiveness of the trend towards proper stocking rates for both range and pasture was rated as follows: 1976 — 1985 — 1985 2 — 3 — 4	1. U.S. Department of Agriculture, The Nations Range Resources, Forest Resource, Rep. No. 19, 1972. U.S. Environmental Protection Agency, Environmental Implications of Trends in Agriculture and Silviculture: Phase I - The Evaluation Workshop Summary, Prepared by Development Planning and Research Associates, Inc.1977.
Productivity	The trend towards proper stocking rates will increase the production and quality of forages on ranges and to a lesser degree on pastures.	2. High-condition, properly grazed range will produce more pounds of usable forage than the total production in pounds of forage from the low-condition, overused range.	2. Bell, A.M., Rangeland Management for Livestock Production, Univ. of Okla. Press, Norman, OK 1973.
		3. A study of grazing in Kansas found that heavily grazed pasture provided an average of only 121 days grazing while moderately and lightly grazed pastures sustained 180 days of use.	3. Launchbaugh, J.L., "The Effect of Stocking Rate on Cattle Gains and on Native Shortgrass Vegetation in West-central Kansas," Kan. Agr. Expt. Sta. Bull. 394, 1957.
		4. Frequent studies of effects of different intensities of grazing upon vegetation have shown that heavy grazing universally reduces the capacity of the range and causes undesirable vegetation changes.	4. Stoddart, L.A., A. D. Smith, and T. W. Box, Range Management, McGraw-Hill, New York, N.Y.,1975.
		5. A study on grazing effects on vegetation on South Dakota rangeland found that over twice as much live vegetation, standing dead and mulch was produced under light grazing as under heavy.	5. Hanlon, C. L., A. R. Kuhlman, C. J. Erickson, and J. K. Lewis, "Grazing Effects on Runoff and Vegetation on Western South Dakota Rangeland," J. Range Management, 23:418-42,, 1970.
		6. Heavy grazing reduces the preferred forage species and promotes the invasion on the range of less desirable forages.	6. Jameson, D.A., "Responses of Individual Plants to Harvesting," Botanical Review,29:532-594,1963.

Exhibit 10.4. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Resource Use	The trend toward proper stocking rates will tend to decrease the requirements for pesticide and fertilizer in range and pasture preservation. The overall reduction is expected to be minor.		
Surface Water	Studies were not found in the literature which related stocking rates specifically to sedimentation and nutrient runoff. However, based on a number of studies on runoff it can be concluded that the trend towards proper stocking rates will reduce nutrient and sediment loadings in surface water.	A study of grazing effects on runoff on western South Dakota rangeland found that: a. Seasonal means of runoff associated with light, moderate, and heavy grazing were significantly different from each other. b. Watersheds with heavy grazing have runoff from short, intense storms as well as from long duration storms. c. Runoff from long duration storms maybe as much from lightly grazed watersheds as from the heavy and moderate.	Reference 5
		7. In the California winter grassland, research found that heavily grazed plots yielded 9.25 inches while lightly grazed yielded only 4.02 inches.	7. Leacos, L.G., "Water yield as Influenced by Degree of Grazing in the California Winter Grasslands," J. Range Management.
		8. A study of the effects of grazing on erosion and runoff in the Chaparral watersheds in central Arizona found that runoff was not affected by grazing intensities.	8. Rich, L. R., and H. G. Reynolds, "Grazing in Relation to Runoff and Erosion in Some Chaparral Watersheds in Central Arizona," J. Range Management, 16:322-326, 1963.
Groundwater	The trend towards proper stocking rates is expected to increase leaching of nutrients into groundwater.	9. Infiltrometer studies conducted on native rangeland at Cottonwood, S. Dak., showed that during the first 30 minutes of rainfall the water intake rate on heavily used pasture was 1.40 inches/hr. while on lightly used, it was 3.19 inches.	9. Rauzi, F. and C. L. Hanson, "Water Intake and Runoff as Affected by Intensity of Grazing," J. Range Management, 19:351-356, 1966.
Soil	High stocking rates results in soil compaction and increased erosion (Ref. 9). Consequently the trend towards proper stocking rates can be expected to enhance soil stabilization.		10. U.S. Department of Agriculture, RPA-ARecommended Renewable Resource Program, Forest Service Environmental Statement, 1976.

Continued . . .

Exhibit 13.4. (Continued)

Environmental Effects	Conclusions	Research Findings	References
Air	Optimizing stocking rates is not expected to effect air quality except indirectly through improved ground cover (Reference 9).		

APPENDIX B

DETAILED ENVIRONMENTAL ASSESSMENT OF SELECTED SILVICULTURAL TRENDS

The five trends identified in Phase I which were selected for assessment in Phase II are listed in Exhibit B-1. A total of 16 subtrends were evaluated. A literature search was conducted for each subtrend's extensiveness of use, productivity effects, changes in resource use, pollutant changes by media, and other environmental effects.

The information obtained from literature searches is summarized in Exhibits 1.1 through 5.1. To the extent possible, quantitative data were sought and included. Also, the extensiveness ratings arrived at in the Phase I evaluation workshop are included for each subtrend. These extensiveness ratings were based on an index scale of 1 to 5, with one representing minor and five major; and, these ratings reflect the judgments of the Composite Phase I panel of silvicultural professionals.

Exhibit B-1. Summary of selected Phase II trends and subtrends in silviculture

Trend	Subtrend
1. Access to Timber Resource	1.1 Permanent road construction 1.2 Road maintenance 1.3 Project road construction 1.4 Road reconstruction
2. Site Preparation	2.1 Log extraction 2.2 Mechanical preparation 2.3 Burning prescription 2.4 Chemical treatment 2.5 Fertilizer treatment 2.6 Soil moisture control
3. Log Extraction	3.1 Harvest unit layout 3.2 Equipment use and development
4. Utilization	4.1 Extraction residue recovery 4.2 Minimum size and quality extension 4.3 Species use enlargement
5. Cutting System	5.1 Clearcutting

Exhibit 1.1. Environmental assessment of selected silvicultural trends
Trend: 1. Access to Timber Resource
Subtrend: 1.1 Permanent Road Construction

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	New road construction is an activity limited almost completely to the West in gaining access to uncut old growth. It will continue through 2010, but will be completed shortly thereafter.	1. Evaluation Workshop Ratings-- 1976 3 ; 1985 2 ; 2010 1 . 2. Road construction will proceed at between 9,000 and 11,000 miles per year. 3. There are now 248,000 miles in logging road systems of the Pacific Coast, with 6,200 miles rebuilt each year.	1. Development Planning and Research Associates, "Environmental Implications of Trends in Agriculture and Silviculture", Vol. I, 200 pp., 1977. 2. U.S. Forest Services, RPA - A Recommended Renewable Resource Program, U.S. Dept. Agri., 650 pp, 1976. 3. U.S. Environmental Protection Agency, Logging Roads and Protection of Water Quality, Region X, 312 pp, 1975.
Productivity	Productivity of Western forest resources will be linked directly to the amount of new road construction, since old growth timber will supply most of Western output.		
Resource Use	Forest land will be taken out of production by construction of the permanent road system with a reduction in the forest resource base. No research was found revealing any estimate of areas involved. There is a need for equipment designed to construct roads of smaller dimension but capable of handling logging traffic. Road design and layout will be planned more intensively.	4. For each square mile of land harvested, 5 miles of road must be built. 5. Road building equipment for highway construction has been used for forest access roads. It is over built for the job. 6. Road location and design are being examined with option of examining many alternatives through use of computer technology.	4. Summer, H. C., "Managing Steep Land for Timber Production in the Northwest", J. Forestry 71(5): 5. U.S. Forest Service, "Region 6 Timber Road Construction Audit", U.S. Dept. Agri., 1973. 6. Burke D., "New Tools Allow Examination of Alternatives Speedily", Forest Industries, Vol. 102 (7), p. 46, 1975.
Pollutant Changes in Media: Surface Water - Sediments	Road construction will continue to create sediment loadings despite improved road construction practices; however, practices should reduce the adverse impacts. Offsetting the effects of better practices will be the effects of entering increasingly steeper and more difficult terrain for road building. Roads once constructed and stabilized will produce little added sediment yield.	7. Available literature did not provide any specific estimates of the effects of road construction, but sediment production is much higher from road building than from any other activity. 8. Average suspended sediment in Western Oregon streams is 1.9 to 131 tons per acre. Eighty percent of sediment production is from roads, 20 percent from logging.	7. Megahan, W. F. and J. W. Kidd, "Effects of Logging Roads on Sediment Production Rates in Idaho Batholith," U.S. Dept. Agri., For. Serv. Res. Pap. Int. 123, 1972. 8. Anderson, H.W., "Suspended sediment discharge as related to stream flow topography, soil and land use," Transaction, Am. Geophysical Union, 35(2) 268-281, 1953.

continued . . .

Exhibit 1.1 (Continued)

Environmental Effects	Conclusions	Research Findings	References
Water Yield	No appreciable change from present rates.		
Water Flow	Depending on degree of engineering and precautions taken to handle peak storm flow along and under roads, flow could be affected with peak bursts if ditches or culverts are obstructed.	No information is available on the predictions of change.	
Water Quality	Water quality in watersheds where road construction occurs will probably suffer less in future than it has in the past. Effects are not felt very far downstream.		
Pollutant Changes in Media: Soil	Mass wasting will be a continuing problem of some severity, but probably lessened with greater attention to protection.	9. In certain fragile areas of the West, slump and mass wasting occur as a result of road construction - as much as 700 times that of undisturbed forests on steep ground.	9. Swanston, D. IV & F.J. Swanson, "Timber Harvesting Mass Erosion and Steepland Forest Geomorphology in the Pacific Northwest", Geomorphology and Engineering, 199-221, Donald R. Coates, Editor, Dowden, Hutchinson and Ross Inc., Stroudsburg, Pa., 1976.
Pollutant Changes in Media: Air	Short term dust creation will occur, but it will occur generally in remote areas away from human habitation. The consequence of this dust is not known.		
Other Environmental Effects: **Aesthetics**	New roads are being designed to minimize visibility for distant viewers by the NFS. While the roads will still be unpleasant for many viewers, the impacts should be lessened.	10. Computer technology is used in selecting road locations from many alternatives.	10. Burke, D., "Automated Analysis of Timber Access Road Alternatives," U.S. Dept. Agri., For. Service Pac. Northwest Forest and Range Experiment Sta. PNW, 123, 1976.

Exhibit 1.2. Environmental assessment of selected silvicultural trends
Trend: 1. Access to Timber Resource
Subtrend: 1.2 Road maintenance

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Maintenance will continue on all permanent access roads where harvest and silviculture treatments occur.	1. Evaluation Workshop Ratings--1976 2 ; 1985 3 ; 2010 4 . 2. Guidelines have been established for minimizing environmental damages from maintenance.	1. Development Planning and Research Associates, Inc., op. cit. 2. U.S. Environmental Protection Agency, Logging Roads and Protection of Water Quality, Region XI, 312 pp., 1975.
Resource Use	No significant changes are anticipated.		
Productivity	Productivity is not directly affected.		
Pollutant Changes in Media: Surface Water - Sediment	Sediment loadings can be expected to occur from maintenance (e.g. road grading in wet weather), but effects will be short lived.	3. Logging roads in Region 6 are being surfaced for better erosion control, lower maintenance, and lower vehicle operating costs.	3. U.S. Forest Service Region VI Engineering Office. Pers. Comm. October 1976.
Chemicals	A trend toward sealing and surfacing roads may result in some chemicals being carried to streamflow.		
Pollutant Changes in Media: Soils	No changes are anticipated.		
Pollutant Changes in Media: Air	Some dust will be generated at intervals, but it will be far removed from population centers.		
Other Environmental Effects: Wildlife	None beyond those incurred by road construction.		
Other Environmental Effects: Aesthetics	No changes are anticipated.		
Other Environmental Effects: Fisheries	No changes are anticipated if precautions are observed and guidelines followed.		

Exhibit 1.3. Environmental assessment of selected silvicultural trends
Trend: 1. Access to Timber Resource
Subtrend: 1.3 Project road construction

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Project roads can be expected to be built in harvest areas throughout U.S.	1. Evaluation Workshop Ratings-- 1976 3 ; 1985 4 ; 2010 3 . 2. In the East, road systems are mostly established, or can be reopened with ease.	1. Development Planning and Research Associates, Inc., op. cit. 2. Ursic S. J., "Harvesting Southern Forests: a Threat to Water Quality?" Nonpoint Sources of Water Pollution, 145-151, Proc. S. E. Regional Conference, Blacksburg, Va., 1975.
Productivity	The expected trend is towards minimizing project road distances to tap given timber harvest areas. In South and North, the construction of project roads will be minimal.	3. Tendency in past has been to overbuild road distances where ground is easy, and to hold to low grades regardless of implications of shortened distances.	3. U.S. Forest Service, "Region 6 Timber and Road Construction AUDIT", U.S. Dept. Agr., 1973.
Resource Use	Forest land will be taken out of production temporarily, but will be allowed to revert. Compaction can be expected to reduce growing area.		
Pollutant Changes in Media	Trend will follow that of new road construction (Subtrend 1.1). As roads become abandoned in the West, measures can be expected to be taken to reduce environmental damages. No significant impacts are anticipated.	4. In Pacific Northwest, methods of restoring road surfaces to original slope are being used.	4. U.S. Environmental Protection Agency, Logging Roads and Protection of Water Quality, Region X, 312 pp, 1975.

Exhibit 1.4. Environmental assessment of selected silvicultural trends
Trend: 1. Access to Timber Resource
Subtrend: 1.4 Road Reconstruction

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Road reconstruction will parallel new (Subtrend 1.1) construction in order to open up regenerating areas and gain entry for silvicultural treatments.	1. Evaluation Workshop Ratings--1976 1 ; 1985 2 ; 2010 3 . 2. Reconstruction in NFS forests is expected to reach almost 30,000 miles per year.	1. Development Planning and Research Associates, Inc., op. cit. 2. U.S. Forest Service, RPA - A Recommended Renewable Resource Program, U.S. Dept. Agr., 658 pp and app., 1976.
Productivity	Some productive forest land will go out of production, either temporarily or permanently depending on class of road.		
Pollutant Changes in Media	Changes will generally be less than those associated with new road construction.	3. Some road reconstruction in West requires more soil disturbance than in original construction.	3. U.S. Environmental Protection Agency, Logging Roads and Protection of Water Quality, Region X, 312 pp, 1975.

Exhibit 2.1. Environmental assessment of selected silvicultural trends
Trend: 2. Site Preparation
Subtrend: 2.1 Log Extraction

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Site preparation overall is an important trend since certain methods are extremely damaging to soil profile. Log extraction is one of the less damaging methods. Since this is a method for preparing sites after harvesting old growth in the West, it will decrease in importance as old growth is removed.	1. Evaluation Workshop Ratings 1976 _3_; 1985 _2_; 2010 _2_.	1. Development Planning and Research Associates, Inc., op. cit.
Productivity	Prompt regeneration can result in significant increase in productivity in the period between first and second harvest. Trend is toward immediate site preparation following harvest, and restocking within the year following.	2. If planting can be done immediately after harvesting in southern pines, yield can be increased. Thus, site preparation is an important step.	2. Committee on Renewable Resources for Industrial Materials (CORRIM), Renewable Resources for Industrial Materials, National Academy of Sciences, 265 pp, Washington D.C., 1976.
Resource Use	Land is being used more efficiently by being returned to production more rapidly; logging methods themselves help prepare site.	3. Logging methods can be used to prepare sites, including supplemental attachments to yarding systems and skidding along contour.	3. Ward, F. R. and J. W. Russell "High Lead Scarification: An Alternative for Site Preparation and Fire Hazard Reduction", Fire Management, Fall 3-4, 9, 1975.
Pollutant Changes in Media: Surface Water - Sediments	No adverse impacts are anticipated unless log movement is parallel to slope, in which case water detachment and transport of soil will occur.	4. Twenty percent of soil sediment discharge is expected to result from harvesting activities.	4. Anderson, H.W., "Relative Contributions of Sediment from Source Areas and Transport Processes," Proc. Symposium, "Forest Land Uses and Stream Environment", pp 55-63, O.S.U. Corvallis, Oregon, 1971.
Water Yield	No change anticipated.		
Water Flow	No change anticipated unless up or downslope log extraction occurs.		Reference # 4.
Chemicals	None involved.		
Nutrients	No change anticipated.		
Pollutant Changes in Media: Soil - Mass Wasting	None anticipated as any result of site preparation by this method, unless excessive up or downslope extraction occurs.		Reference # 4.
Erosion	Some erosion may occur, but it is not expected to be extensive.		
Pollutant Changes in Media: Air - Dust	Some dust may be generated, but it is not expected to be of significant consequence.		

Exhibit 2.2. Environmental assessment of selected silvicultural trends
Trend: 2. Site Preparation
Subtrend: 2.2 Mechanical Preparation

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Varies greatly by region of the country, with greatest utilization in the South and the Pacific Coast. The trend is expected to be away from mechanical means because of impact on soils and water. On the Pacific Coast, normal logging operations will provide much of the site preparation required.	1. Evaluation Workshop Rating -- 1976 3 ; 1985 4 ; 2010 3 . 2. In the South, some 29.6 million acres are considered to need conversion to pine type, involving site preparation of some kind. 3. Between 1967 and 1977, forest industry was expected to drain 2 million acres and prepare another 3.7 million acres for planting. 4. Intensive mechanical site preparation is the most serious erosion problem in the Southern hill country. 5. In the Pacific Coast, 3 million acres of alder are convertible to conifer species. 6. In the West, specialized modifications of standards cable yarding systems are being developed to scarify logged sites.	1. Development Planning and Research Associates, Inc., op. cit. 2. Guttenberg, S., "Forestry Goals and Practices on Large Ownerships in the South," J. Forestry, 67(7): 456-461, 1969. 4. Ursic, S. J., "Pine Management Influences the Southern Center Resource", Proc. Symposium of Young Pines, 1974. 5. Committee on Renewable Resources for Industrial Materials (CORRIM), Renewable Resources for Industrial Materials, National Academy of Sciences, 265 pp, Washington D.C., 1976. 6. Ward, F. R. and J. W. Russell, "High Lead Scarification: An Alternative for Site Preparation and Fire Hazard Reduction," Fire Management, Fall 3-4, 9, 1975.
Pollutant Changes in Media: Surface Water	Serious problems will continue if recommended precautions are ignored.	7. Loss of forest floor, soil compaction and sealing macro channels change surface flow.	7. Beasley, R. S., "Potential Effects of Forest Management on Stormflow Survey and Water Quality," Proc. Miss. Water Resources Conference, 1976.

Exhibit 2.3. Environmental assessment of selected silvicultural trends
Trend: 2. Site Preparation
Subtrend: 2.3 Burning Prescription

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Fire probably will be used increasingly as a partial substitute for mechanical site preparation as well as other uses (e.g. timber, stand improvement, fuel reduction).	1. Evaluation Workshop Ratings-- 1976 3 ; 1985 3 ; 2010 3 . 2. Annual needs for prescribed burning amounts to about 12 million acres per year, 95% in South. How much is used in site preparation is not known. 3. Substituting burning in place of mechanical site preparation will conserve energy and do far less damage. There is no need to prepare as thoroughly as is done with mechanical preparation.	1. Development Planning and Research Associates, Inc., op. cit. 2. McNamara, E. F., "Fire Management on State and Forest Lands," Proc. 1974 National Convention, Soc. Am. Foresters, New York, 1975. 3. Smith, D. M., ""Modern Timber Management with Petroleum," Proc. 1976 National Convention Society of American Foresters, 1976.
Productivity	Productivity can be improved temporarily by fire used in site preparation as result of nutrients being released.	4. The use of prescribed burning may be decreasing in the South as result of air quality standards being tightened. 5. Fire is least energy - demanding method of site preparation.	4. Zobell, B., "Significance of Forest Renewable and Tree Improvement to Forest Farmers," Forest Farmer, Vol. 35, No. 6, p 44, 1976. 5. Reference # 3.
Pollutant Changes in Media: Surface Water	Short term water yield and flow increases can be expected until new vegetative cover establishes; otherwise no significant effects can be expected.		
Other Environmental Effects: Wildlife	Wildlife and vegetation undergo complete changes, with new ecosystems being created.		
Other Environmental Effects: Aesthetics	Short term adverse viewing experiences can be anticipated.		

Exhibit 2.4. Environmental assessment of selected silvicultural trends
Trend: 2. Site Preparation
Subtrend: 2.4. Chemical Treatment

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Chemicals' importance as a beneficial tool in site preparation is expected to increase. Federal lands are expected to receive extensive chemical treatment. A restraint to widespread use is cost.	1. Workshop Panel Ratings-- 1976 _1_; 1985 _2_; 2010 _2_. 2. In the South where the most intensive forestry is practiced, less than 1 per cent of commercial forest had pesticide applications. On the Pacific Coast, State of Washington, 0.8 per cent had pesticides applied. 3. Chemicals are included in Forest Service Best Management Guidelines for site preparation.	1. Development Planning and Research Associates, Inc., op. cit. 2. Johnson, N. E., "Pesticide Usage in Forestry," J. Forestry, 5:546-548, 1972. 3. Oregon State University, Silvicultural Chemicals and Protection of Water Quality, (draft), Corvallis, Oregon, 1976.
Productivity	Productivity of wood fibre will be increased by shortening the period for establishing a new stand of timber. But applications of chemicals alone cannot accomplish this. Subsequent follow up is required.		
Resource Use	Total area receiving chemical treatment is extremely small when compared to the total area forested.		Reference # 2.
Pollutant Changes in Media: Surface Water	Effects of chemical treatment on surface water are not expected to be significant.	4. Guidelines establishing protection by buffer strips around water bodies will prevent any fallout of herbicides applied aerially. Herbicides have least chance of damaging aquatic fauna.	4. Reference # 3.
		5. In site preparation, application are generally made only once with maximum of twice in a rotation.	5. Reference # 2.
		6. Tree injected with arsenicals showed no increase in stream water arsenic content.	6. Norris, L. A. and D. C. Morre, "Behavior and Impact of Organic Arsenical Herbicides in the Forest, U.S. Dept. Agr. for Ser PNW Experiment Station, 1974.

Continued . . .

Exhibit 2.4 (Continued)

Environmental Effects	Conclusions	Research Findings	References
Pollutant Changes in Media: Soil	No significant effects are anticipated.	7. Commonly used herbicides break down organically. Residues of 2,4,5-T at concentrations of 11-12 ppm drop to 0.2-0.5 ppm within 12 months. They do not travel laterally.	7. Norris, L. A., "Behavior and Impact of Some Herbicides in Forests," John S. Wright Forestry Conference, Purdue U., West Lafayette, Ind., 1975.
Other Environmental Effects: Wildlife	Disruptions will continue to occur with abrupt changes in vegetation.		
Vegetation	Broad leafed vegetation is eliminated under chemical treatment.		
Aquatic Habitat	The aquatic habitat may be adversely affected if chemicals are applied directly to surface water. However, guidelines have been established which are expected to minimize the chances of this direct contamination.	8. Guidelines established for minimizing drift of aerially applied chemicals.	8. Grathowski, H., "Silvicultural Use of Herbicides in Northwest Forests, U.S. Dept. Agr., Forest Service, Tech. Rep. PNW 37, 44 pp, 1975.
Human Health	The total use of herbicides in site preparation nationwide is expected to be so low that human health should not be significantly affected.		

Exhibit 2.5. Environmental assessment of selected silvicultural trends
Trend: 2. Site Preparation
Subtrend: 2.5. Fertilizer Treatment

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Fertilizer treatment is used primarily in the South, where moist, phosphate deficient soils need nutrient supplement for the growth of loblolly pine.	1. Workshop Panel Ratings-- 1976 1 ; 1985 2 ; 2010 2 . 2. Used only to add phosphorus to swampy areas drained for loblolly pine establishment in the South. Phosphorus applications have not affected water quality to any measurable degree.	1. Development Planning and Research Associates, Inc., op. cit. 2. Personal communication with George Dissmeyer, U.S. Forest Service, Atlanta, Georgia, 1977.
Productivity	The creation of new pine forests will reflect an increase in productivity.	3. About 2.0 million acres of swamp land in South are expected to be drained for pine production by 1977.	3. McClurkin, D. C. and P. D. Duffy, "Evaluating Impact of Forest Site Preparation on Soil and Water Quality in the United States," Proc. Fourth N. Am. Forest Soils Conf., Quebec, Canada, 1973.
Resource Use	Fertilizer requirements are expected to range from 5,000 to 20,000 tons per year. If swamp land is prepared at a steady rate, the South would need 4,500 to 18,000 metric tons per year. Amount of swamp land remaining is unknown.	4. Phosphates are expected to be applied at rates of 50 to 200 lbs/acre.	4. U.S. Environmental Protection Agency, Logging Roads and Protection of Water Quality, Region X, 312 pp., 1975.
Pollutant Changes: Water	Phosphate levels in surface water are expected to increase; however, the increase will be relatively minor.	5. Little is known about water quality changes as result of phosphate fertilizing, but slight losses from fertilized sites indicate movement into water.	5. Sanderford, S.G., "Forest Fertilization and Water Quality in the North Carolina Piedmont," Tech. Report 53, North Carolina State Fertilizer Coop., 42 pp., 1975.

Exhibit 2.6. Environmental assessment of selected silvicultural trends
Trend: 2. Site Preparation
Subtrend: 2.6. Soil Moisture Control

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	About 2.0 million acres of wetland are expected to be drained in the South by 1977. (Reference 2)	1. Evaluation Workshop Ratings-- 1976 2 ; 1985 2 ; 2010 1 .	1. Development Planning and Research Associates, Inc., op. cit. 2. McClurkin, D. C. and P. D. Duffy, "Evaluation Impact of Forest Site Preparation on Soil and Water Quality in the United States," Proc. Fourth N. Am. Forest Soils Conf., Quebec, Canada, 1973.
Productivity	Swamp lands with zero productivity are being converted to pine producing sites.		
Resource Use	Drainage of swamp lands represents conversion to productive land use from non-productive use.		
Pollutant Changes--Media: Surface Water	Slight increases in stream flow in watersheds draining swampy areas can be expected.		
Wildlife and Vegetation	Plant species and wildlife existing in the wetlands will be replaced with the limited diversity of pine forests.		

Exhibit 3.1. Environmental assessment of selected silvicultural trends
Trend: 3. Log Extractions
Subtrend: 3.1. Harvest Unit Layout - Intensity of Effort

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Planning will play an increasingly important role in Western old growth timber stands in determining locations, size of harvest units, design or shape of cutting areas, considerations to visibility, road access, and other aspects of multiple use.	1. Evaluation Workshop Ratings-- 1976 3 ; 1985 4 ; 2010 4 . 2. Techniques are being developed for gauging aesthetic impacts of logging on roadside viewing. 3. The development of computer programs for designing harvest operations and determining road locations facilitate the study of many alternatives.	1. Development Planning and Research Associates, Inc., op. cit. 2. Polter, D. R. and J. A. Wagar, "Techniques for Inventorying Man Made Impacts on Roadway Environments," U.S. Dept. Agr., Forest Services, Research Paper, PNW 121, 1971. 3. Burke, "Doyle, Running Skylines Reduce Access Road Needs Minimize Harvest Impact," Forest Industries, Vol. 102:(7), p. 46, 1975. 3a. "Topometrics, A System for Evaluating Route Alternatives," Nat. Agr. Sciences Trans. Res. Bd. Sp. Reproduction 160, pp. 141-145, 1975.
Productivity	In terms of roundwood production, productivity is not expected to increase, except to the extent that planning may aid in increasing utilization.		
Resource Use	The only increase in resource use expected is in the field of utilization, especially in residues of old growth logging, and whole tree utilization in the South (see Trend 4, Utilization).		
Pollutant Changes: Surface Water - Sediments	Increasing control over movement of water and transport of sediments will be gained but problems will continue to persist, especially in the sheep ground of the West.	4. Continuing research and development of programs for more effective management are being formulated.	4. U.S. Forest Service, A National Program for Research and Development on Non-Point Source Water Pollution on Forest and Rangeland, Wash. D. C., (Review Draft), Washington, D.C., 1976.

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Exhibit 3.1 (Continued)

Environmental Effects	Conclusions	Research Findings	References
Wildlife	No substantial changes from usual harvesting planning are expected unless planning is directed specifically at habitat modification as result of harvest plans.		
Fisheries	Increasing protection of existing temperatures and streambed structure is expected.		
Aesthetics and Viewing	Continuing development of harvesting plans to reduce or minimize effect on viewer of harvested lands can be expected.	5. Plans in Pacific Coast include road screening, distant view considerations, and successive harvests hidden by uncut bands of timber.	5. Bureau of Land Management, Timber Management Plan, Final Environmental Impact Statement, 584 pp. Washington D.C., 1976.

Exhibit 3.2. Environmental assessment of selected silvicultural trends
Trend: 3. Log Extraction
Subtrend: 3.2. Equipment Use and Development

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	On the Pacific Coast, a continuing need will exist for large equipment modified to reduce environmental damages. This will probably involve the development of lighter more mobile yarding equipment for entry into younger stands for thinning. In the South, a trend is developing for equipment designed for whole tree handling of timber of uniform size.	1. Workshop Panel Ratings-- 1976 3 ; 1985 4 ; 2010 5 . 2. Increasing use of modified cable systems is reducing road needs. 3. Light yarding equipment coming into use in Pacific Coast is more efficient and less damaging in thinning operations.	1. Development Planning and Research Associates, Inc., op. cit. 2. Burke, Doyle, "Running Skylines Reduce Access Road Needs Minimize Harvest Site Impact," Forest Industries, Vol. 102:(7), p. 46, 1975. 3. Kellogg, L. and E. Aurlich, "Prebunch and Swing Technique May Reduce Thinning Costs," Forest Industries, Vol. 104(2), p. 30, 1977.
Productivity	Environmental constraints can be expected to limit productivity in a number of situations, but the overall trend is toward increasing productivity, especially in regenerating stands where thinning takes place.		
Resource Use	The requirement for resources used in developing and supplying equipment will increase significantly, especially with the demands in the North and South.	4. Timber production will increase markedly in the North and South: North--from 47 million m^3 to 94 million m^3; South from 159 mm m^3 to 329 mm m^3; and West--from 165 mm m^3 to 270 mm m^3. A doubling of production implies a corresponding increase in equipment needs.	4. "Outlook for Timber in the United States," For. Serv. Rept. 20, 367 pp., 1973, USDA Forest Service, RPA, A Recommended Renewable Resource Program, 658 pp. and App., 1976.
Pollutant Changes in Media: Surface Water	Equipment changes are expected to reduce surface water pollution.		
Air	Exhaust emissions and dust are expected to increase with the increase in woods activity.		
Soil	A trend toward the use of high flotation tires in skidders can be expected.	5. Skidder wheel tracks need 12 years to recover from compaction, while the skid marks of logs require 8 years.	5. Dickerson, B.P., "Soil Compaction After Tree Length Skidding in Northern Mississippi," Soil Sci. Am. J., 40(6):96, 1969.

Exhibit 4.1. Environmental assessment of selected silvicultural trends
Trend 4: 4. Utilization
Subtrend: 4.1. Extraction Residue Recovery

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Significant increases are expected to occur in recovery of extraction residues. Currently, almost a half of the total unused residues are being generated in the Pacific Coast forests. Whole tree utilization is expected to double in the South. Complete tree removal has the potential of increasing utilization by about 25 percent. The expected increase in extraction residue recovery can be attributed both to economic and social factors as well as technological developments.	1. Evaluation Workshop Ratings-- 1976 _3_; 1985 _3_; 2010 _1_.	1. Development Planning and Research Associates, Inc., _op. cit_.
		2. Almost one half the total unused woods residues in the nation are generated in Pacific Coast forests.	2. Corder, S. E., "Wood and Bark Residues for Energy," P. 7, Proc. Conference, O.S.U., Corvallis, 1974.
		3. Bark is developing as a new energy source, via conversion to gas or liquid fuel.	3. U.S. Forest Service, "Properties and Uses of Bark as an Energy Source," Dept. Agr. USFS Res. Paper PNW 31, Forest Research Lab O.S.U., Corvallis, Oregon, 1976.
		4. Costs of bringing in woods residue vary from $34 to $43 per ton for chips and $31 to $40 for hogged fuel.	4. Grantham, J. B., E. M. Estap, H. Tarkow and T. C. Adams, "Energy and Raw Material Potential of Wood Residue in Pacific Coast States," 1974.
		5. Potential for increasing utilization through complete tree removal is estimated at an additional 25 percent. Current utilization of 30 cm stump height and 10 cm utilizable top diameter leaves half of the biomass of a tree in the woods.	5. Committee on Renewable Resources for Industrial Materials (CORRIM), _Renewable Resources for Industrial Materials, National Academy of Sciences_, 265 pp., Washington, D. C., 1976.
		6. In the South, whole tree utilization in hardwoods is expected to increase biomass utilization from 30 percent to 67 percent.	6. Koch, P., "Key to Utilization of Hardwoods: The Shaping Lathe Headrig," _Forest Industries_, 103 (11):48-51, 1976.
		7. More complete utilization will: -Add over [illegible] million tons of utilizable raw material annually -Protect soils -Decrease air pollution -Reduce debris in streams -Improve scenic values -Improve recreational opportunities -Reduce public criticism.	7. Grantham, J. B., "Status of Timber Utilization on Pacific Coast," Dept. Agr., Forest Service, Gen. Tech. Rep. PNW 29, 1976.
		8. Logging residues cost $30 per dry ton delivered, as opposed to $2.50 for hogged mill wastes $10 for planer shavings, and $20 for chips.	8. Reference 7.
		9. Advances in materials handling such as grapple yarder is helping to recover more residues from logging operation.	9. Reference 3.

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Exhibit 4.1 (Continued)

Environmental Effects	Conclusions	Research Findings	References
		10. Utilization of tree stem is increasing. Younger stands provide less unmerchantable or cull volumes. Thinnings are taking most defective material.	10. Ruth, R. H. and A. S. Harris, "Forest Residues in Hemlock Spruce Forests of Pacific Northwest and Alaska," U.S. Dept. Agr. Forest Ser., Gen. Tech. Rep. 39, 1975.
Productivity	Increasing recovery of material now left in woods will add substantially to annual supply of pulpable fibre and combustible fuel.	11. One cubic meter of hogged bark has thermal content of .09 cubic meters of Number 4 oil.	11. Reference 3.
		12. NFS lands have 3 times as much residue left as private industry lands in Pacific Northwest. Old growth will be largely liquidated in the West between 2020 and 2040.	12. U.S. Forest Service, "Douglas Fir Supply Study," Regions 5 and 6 PNW, Forest and Range Exp. Station, Portland, Oregon, 51 pp., 1969.
Resource Use	Resource use will intensify in terms of extraction activity per acre.		
Pollutant Changes in Media:	In general, pollutant changes in media will reflect an improvement. However, possibilities will exist for increased soil disturbance and road use.		
Surface Water	Debris content of streams will be reduced.		
Soils	Protection of soil structure by minimizing burning of slash will be offset to some extent by increased soil disturbance in yarding increased volumes of material per unit area.		
Air	Air pollution from slash burning will decrease.		
Other Environmental Effects--Aesthetics	Adverse scenic impacts will be reduced.	13. Tendency should be toward lessened public criticism.	13. Reference 3.
Other Uses	Recreation value of logged areas will increase during regeneration period.	14. Opportunities will exist for easier access, berry picking, wildlife viewing.	14. Reference 3.
Wildlife	Access and movement will be easier for big game.		

Exhibit 4.2. Environmental assessment of selected silvicultural trends
Trend: 4. Utilization
Subtrend: 4.2. Minimum Size and Quality Extension

Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Significant increases are expected in the practice of minimum size and quality extension. This trend is particularly apparent in the South.	1. Evaluation Workshop Ratings-- 1976 3 ; 1985 3 ; 2010 1 . 2. In the South extracting the whole tree including roots facilitates a 20 percent increase in utilizable fibre. 3. In eastern hardwoods, tops of harvested trees yielded 7 cubic meters/acre of sawn products and 23 tons of chippable wood.	1. Development Planning and Research Associates, Inc., op. cit. 2. Koch, P., "Key to Utilization of Hardwoods: The Sahping Lathe Headrig," Forest Industries, 103 (11):48-51, 1976. 3. Craft, E. P., "Utilizing Hardwood Residues, A Case Study in the Appalachians," U.S. Dept. Agr., For. Serv. Res., Note NE 22.
Productivity	The potential for taking advantage of unused tops and species will depend on status of industry, regionally and subregionally.	4. Pacific Coast pulping raw material is derived 85 percent from residues of sawmills and plywood plants. 5. In South material is derived 72.5 percent from roundwood material 27.5 percent from chips (some of which produced from roundwood.) In South 45 m^3/ha of chippable wood left after clearcut.	4. Grantham, V. B., "Status of Timber Utilization on the Pacific Coast," U.S. Dept. Agr., Forest Serv., Gen. Tech. Rep. PNW 29, 1976. 5. "1976 Southern Pulpwood Production Sets Another Record; up 4 percent," Forest Industries, Vol. 103 (6), June 19, 1976. 5a. Chappell, T. W. and R. C. Beetz, "Southern Logging Residues; Opportunity," J Forestry 71:11, p. 688, 1973.
Resource Use	Increased utilization through minimum size and quality extension will increase activity per unit area harvested.		
Pollutant Changes in Media: Surface Water	If tree pulling and whole tree utilization becomes a common practice in the South, nutrient deficiencies will occur.		
Soils	An increase in soil disturbance and compaction can be expected.		

Exhibit 4.3. Environmental assessment of selected silvicultural trends
Trend: 4. Utilization
Subtrend: 4.3. Species Use Enlargement

Environmental Effects	Conclusions	Research Findings	Reference
Extensiveness	Species use enlargement is expected to involve the utilization of more hardwood species of North and South, and alder and aspen in West.	1. Evaluation Workshop Ratings-- 1976 _2_; 1985 _3_; 2010 _4_.	1. Development Planning and Research Associates, Inc., _op. cit._
Productivity	Productivity of some areas of country will increase as more species become available but conversion to pure stands in many instances will probably tend to decrease future utilization in terms of volume.	2. The utilization of hardwood in the South rose from 12.7 million cubic meters in 1964 to 21.4 million in 1974.	2. "Pulpwood Statistics," Forest Industry, Vol. 103(6), p. 6, June 1976.
Resource Use	Resource use is expected to increase with the removal of a greater volume per unit area.	3. Hardwoods in pulp expected to increase from 23 percent of all pulpwood production in 1970 to 35 percent by 2010.	3. "Outlook for Timber," Forest Service Report 20, 367 pp., 1973. USDA Forest Service, RPA, A Recommended Renewable Resource Program, 658 pp. and App., 1976.
Pollution Changes in Media: Surface Water - Sediments	Soil disturbance should be decreased especially in the South, where increasing species removal will result in less need for heavy equipment in site preparation.		
Other Environmental Effects: Wildlife	Changes will occur with conversion to monoculture.		

Exhibit 5.1. Environmental assessment of selected silvicultural trends
Trend: 5. Cutting Systems
Subtrend: 5.1. Clearcutting

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Environmental Effects	Conclusions	Research Findings	References
Extensiveness	Clearcutting as a system is increasing. Evenaged management is demonstrating greatest potential for maximizing fibre yield in a number of forest types, and clearcutting provides best opportunity for establishment of new stands. Clearcutting is also target of criticism because its use, especially on old growth stands, causes immediate aesthetic degradation and can result in damages to water and soil. It effectively dedicates land to fibre production to the detriment of other uses. Possibility exists for future limiting of clearcuts on federal lands, resulting from public pressures. Future trends in clearcutting will be to limit visual affront and other damages by selection of size, shape, location, use of road screens and stream buffers.	1. Workshop Panel Ratings-- 1976 _4_; 1985 _3_; 2010 _5_. 2. Most damages associated with clearcutting are actually results of other activities--railroad logging, road building, repeated unchecked fares on logging sites, and lack of residue recovery. 3. A combination of shelpwood and clearcut in patches has been adopted as a policy by Bureau of Land Management in conducting timber sales.	1. Development Planning and Research Associates, Inc., Environmental Implications of Trends in Agriculture and Silviculture, Vol. I, U.S. Environmental Protection Agency, 200 pp, 1977. 2. Smith, D.M., Modern Timber Management Without Petroleum, Proc., 1976 National Convention Society of American Foresters, 1976. 3. Bureau of Land Management, Timber Management, Final Environmental Impact Statement, 584 pp, Washington, D.C., 1976.
Productivity	Evenaged management favors quick reestablishment of regeneration, which effectively shortens rotation. Species responding are generally desirable in market and show strong growth characteristics. Consequently, productivity will be higher where such establishment replaces unevenaged mixed stands. Judicious use of clearcut will increase productivity of fibre but will inevitably depreciate other values.	4. Areas opened up by clearcutting favor quick establishment of species. 5. Of 37 major forest types, clearcutting used in at least 20 as a standard method.	4. U.S. Forest Service, Silvicultural Systems of the Major Forest Types of the United States, U.S. Dept. of Agr., Handbook 445, 124 pp. 5. Reference 4.
Resource Use	No changes anticipated.		
Pollutant Changes in Media: Surface Water - Sediments	Clearcuts can and do result in sediments and erosion but care in location, size and logging method can minimize these problems. Trend in future will be toward such practices.	6. Clearcutting and harvesting seldom disturbs more than 30 percent of the pre-soil surface area.	6. Beasley, R.S., "Potential Effects of Forest Management on Stormflow Survey and Water Quality," Proc. Misc. Water Resources Conf., 1976.

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Exhibit 5.1 (Continued)

Environmental Effects	Conclusions	Research Findings	References
Water Yield and Flow	Clearcutting should continue to be a useful tool in increasing water yield in Rockies through snow entrapment in openings created.	7. Timber clearcutting techniques in Rockies has proven to be an effective means of increasing yield and flow of water.	7. Hover, M.D. "Vegetation Management for Water Yield," Symposium of Water Balance in North America, Proc. Ser. 7 pp 191-195, 1969.
	Clearcutting on Pacific Coast can result in short term increases that drop as vegetation re-establishes. In Rockies, timing of cut controls flow and erosion potential.	8. Individual clearcuts of less than 5 percent of a given watershed probably do not affect downstream flows. The slight effect would be lost by worse damage connected with roads, plugged drains, loose soil, etc. Both cut and uncut areas respond about equally to heavy storm conditions in Rocky Mountains. Timing of cutting can minimize or avoid channel erosion.	8. Harr, A.D., Forest Practices and Streamflow in Western Oregon, U.S. Dept. Agr., Forest Service, Tech. Rep. PNN 49, 1976.
Water Quality	Exercised with care, clearcutting can be carried out without impairing water quality. Ongoing work to minimize effects should result in more protection, but temperature and sediment loads can be affected.	9. In North, it is possible to harvest clearcut lands at no significant damage to water quality.	9. Aubertin, G.M. and J.H. Patric, "Quality Water from Clearcut Land", Northern Logger, 20(8): 14-15, 1972. 9a. Hornbeck, J.W., "Protecting Water Quality During and After Clearcutting," J. Soil and Water Conservation, 23(1):19-20, 1968.
Soils - Mass Wasting	Without close knowledge and care in handling of slope under soil conditions, mass wasting can occur from large clear cuts, but this is more often the result of roads than cutting, per se. Trend is toward smaller, shaped cuts.	10. Large clearcuts have resulted in debris avalanches accelerated by expanses of bare ground, but harvesting itself was responsible for ground baring.	10. Bishop, D. and M.E. Stevens, Landslides on Logged Aneasin S.E. Alaska, U.S. Dept. Agr., Forest Service, Res. Paper NOR-1, 18 pp, 1964.
		11. In a 6 year period, clearcut without roads had 2 percent of land slide activity of clearcut roads, but clearcutting can stop nutrient uptake, reduce organic matter, and increase soil erosion potential.	11. Frederickson, R.L., "Impact of Forest Management on Stream Water Quality in Western Oregon," Proc. Symposium of Water Pollution and Abatement, Forest Products Research Society, 1972.
Other Environmental Effects: Aesthetics	It is becoming increasingly possible and practical to handle clearcuts so as to minimize adverse environmental impacts, including aesthetics. A combination of clear cuts and shelter, wood cuts will most likely continue. However, with decreasing size of clearcut more roads are required, which results in greater environmental problems than clearcutting itself.	12. The use of computer technology with maps and data memory storage allows study of map alternatives for arriving at optimum harvest plan.	12. Burke D., "New Tools Allow Examination of Alternatives Speedily," Forest Industries, Vol. 102:(7), pp 48-50, Vol. 102:(8), p. 44, June 1975.

Exhibit 5.1 (Continued)

Environmental Effects	Conclusions	Research Findings	References
Wildlife	The wildlife make-up changes with clearcutting, from tree and forest dwelling found to be more open dwelling. With the creation of new edge between vegetation types, wildlife should be more diverse, with increased interim browse for ungulates, and more habitat for brush dwelling species.	13. Birdlife on clearcut changes significantly. Populations drop in first few months, building up to greater than pre-harvest by third year for all brush and ground dwellers. By Year 12, tree dwelling species appear again.	13. Conner, R.R. and C.S. Adkisson, "Effects of Clearcutting on Diversity of Breeding Birds," J. Forestry, 73(12):781, 1975.
Aquatic Systems	Aquatic systems will continue to receive some adverse impact, but these will be limited wherever precautions are taken.	14. Use of buffer strips will both impede surface runoff and maintain stable water temperatures, helping to sustain heating fisheries.	14. U.S. Forest Service, RPA- A Recommended Renewable Resource Program, U.S. Dept. Agr., 652 p., 658 pp and App., 1976.